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VOLUME II APRIL, 1916 No. 4

OBSERVATIONS ON SOME DISEASES OF PLANTATION RUBBER IN MALAYA.

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Senior Demonstrator of Botany, Cambridge University; sometime Government Mycologist, Federated Malay States.

(With Plates XXXIII—XXXV.)

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1. *Introduction.*

THE present paper is an account of observations made upon some diseases of plantation rubber while the writer was acting as Government Mycologist in the Federated Malay States during 1914. Accounts of Pink Disease caused by *Corticium salmonicolor* and of the disease caused by *Ustulina zonata* have been published in separate papers (5, 7) and are only briefly mentioned here.

Generally speaking, Para rubber is a particularly healthy tree not only in its home in the valley of the Amazon but also in Ceylon, Malaya, Borneo, Java, and Sumatra, where such enormous areas have been

planted with it that the plantation industry is superseding the collection of rubber from wild sources. In Malaya large numbers of estates are contiguous to one another, and in travelling by rail from Penang to the borders of Johore one passes through an almost continuous rubber forest, broken here and there by other cultivations or by tin-mining areas and only once interrupted by a considerable jungle belt. These estates are usually devoid of inter-crops, hence this enormous tract of country, planted with a single product, would offer favourable opportunities for the establishment of disease on a serious scale were it not for the robust nature of *Hevea brasiliensis*, its relative immunity from disease, and the measures already taken to check fungoid parasites. Fortunately no disease of an epidemic nature has yet attacked plantation rubber with the possible exception of Pink Disease (7), which sometimes affects numbers of trees simultaneously in certain parts of the country during wet weather. It is probable, however, that Pink Disease can be kept under control if proper precautions are taken. No serious leaf disease of *Hevea* has yet been recorded in the East and the type of leaf, thin but tough, is one not specially liable to fungoid attack. One can safely say that plantation rubber is at present at least as healthy as most of the agricultural crops of temperate countries.

Although plantation rubber has been so healthy hitherto it must be emphasised that this happy state can only be maintained by continued vigilance in the treatment of disease as soon as it appears. The planting of enormous areas with one kind of plant offers special facilities for the propagation of disease unless any danger which threatens is dealt with drastically at once. It is fortunate for the plantation rubber industry that planters as a body are keen to combat disease and it is now the rule on estates to seek expert assistance as soon as troubles of this nature arise. Planters have by experience developed sound views on the subject of plant sanitation. The ravages of *Hemileia vastatrix* and other injurious organisms upon coffee in Ceylon has made a deep impression upon them. Many Malayan planters were formerly planters in Ceylon where they had actual experience of the effect of disease in the coffee industry or heard about it from the older men, and not a few saw similar ravages upon coffee in the Federated Malay States before the cultivation of this crop on a large scale was abandoned.

Within the last few years estate practices have changed in a direction that conduces to maximum vigour in the trees. Whereas it was formerly customary to plant 350 and more trees to the acre it is now usual to

plant only about 100 per acre. On many older estates thinning out has reduced the number of trees per acre to 80 or 90. Now that overcrowding is prevented the trees have a better chance of attaining their natural habit of growth, and air and light being freely admitted to all parts of the tree there is less danger of the establishment of disease. Where estates are thinned out it is necessary for the rubber stumps to be removed from well below the surface of the ground, otherwise there will be danger of root troubles later.

The methods of tapping in vogue at present are much more conservative than those formerly practised and longer periods are allowed for bark renewal, all of which tends to preserve the health and vigour of the trees. Many of the older trees were overtapped during the boom of 1910 and in consequence are poor specimens at the present day.

On account of the reduction in the number of trees per acre on most estates in comparison with the number formerly customary, each tree is now of more value as a potential or actual latex producer, for in the long run an acre bearing 100 trees will yield more rubber than an acre in which 350 trees remain. An estate containing 80 to 90 trees per acre cannot afford to lose many trees through disease, hence the smaller the number of trees per acre the more important does it become to do everything possible to ensure vigour in the trees and, if disease does appear, to treat it as soon as possible. The retention of only 40 trees per acre has been advocated by some authorities but the loss of a few of these trees from disease would cause such a serious reduction in the output of latex that upon this consideration alone it would appear preferable to retain about 80 trees to the acre.

When trees are killed by disease in plantations more than two or three years old it is usually not worth while to replant vacancies as supplies become crowded out by the older trees unless the vacant areas are extensive.

It is found advisable on most estates to keep a special coolie gang to deal regularly with pests and diseases, the size of the gang being regulated according to the amount of work to be done. Upon estates affected by Pink Disease the maintenance of a pest gang sufficiently large to go over the whole estate once in three or four weeks is an imperative necessity. European supervision should always be exercised over the treatment of disease although coolies often become remarkably expert in finding unhealthy trees.

As is only natural, managers of estates sometimes express regret at the cost of the pest gang though many of them realise that money

so spent is in the nature of insurance for the future. The welfare of the plantation rubber industry is dependent upon many factors, but it is obvious that without health in the trees this flourishing industry would cease to exist.

2. *Fomes lignosus*, Klotzsch.

This fungus which is the commonest cause of root disease of *Hevea* in Malaya is better known under the name, *Fomes semitostus*. Petch (11), however, has pointed out that *Fomes semitostus* proper is an entirely different fungus and that the correct designation of the fungus causing root disease of *Hevea* is *Fomes lignosus*, Klotzsch.

Soon after the establishment of rubber estates upon an extensive scale in Malaya this fungus became particularly troublesome in young plantations. As is well known it begins to grow upon the stumps which remain after the operations involved in planting up jungle land, and spreads thence by means of thick, yellowish white, mycelial strands which travel underground to the roots of young rubber trees. When the mycelium reaches the collar of the tree and spreads around it the tree dies.

Until recently the only mode of treatment for this disease used on a large scale lay in the destruction of affected trees and the isolation of diseased areas by means of trenches, but according to Richards (12) and Colenbrander (9) considerable success has been obtained by treating the roots of trees in the early stages of attack in the following manner. All trees are examined by opening the soil around the collar and if traces of mycelium are found the roots are fully exposed. Dead portions of roots are cut off, the external mycelium around living parts is scraped away, and the surfaces are then covered with a thin Bordeaux paste. The surrounding area is dug, all mycelial strands and dead wood being burnt. Richards (12) states that 75 per cent. of the trees affected on some estates have been successfully treated in this manner. A method similar to the above, but in which carbolineum is used instead of Bordeaux mixture, is described by Rutgers and Arens (16) as being used in Sumatra by Ris.

Since *Fomes lignosus* has been recognised to be a serious root parasite it has become customary on some estates to clear the land of jungle stumps and other timber a few years after planting. The cost of clearing varies greatly in different districts and depends largely upon the relative heaviness of the jungle that formerly covered the ground. Some of

the stumps of old forest trees are so large and so resistant to decay that it is very expensive to remove them. Where, however, stumping can be carried out at a low figure before the estate comes into bearing the operation insures against serious attacks of root disease and facilitates the movements of coolies engaged in weeding and tapping. If the cost of clearing the timber is high, and *Fomes* does not threaten seriously, the cheapest course will probably be to treat root disease as it appears.

Even on estates which are apparently equally encumbered with timber the prevalence of *Fomes* varies greatly. Some plantations are seriously troubled by it in the early years, others are never much affected. Soils which are either very loose or clayey seem to favour the disease, soils of an intermediate character being less liable to it. The underground strands of the fungus are sometimes found at a depth of two and a half feet in loose soils but usually they are not more than 18 inches below the surface.

As Petch (10) points out, trees that are invaded by white ants have generally been previously attacked by *Fomes lignosus*. When such trees have been blown over, examination often fails to reveal signs of the fungus which together with much of the diseased wood has been consumed by the termites.

Even though the stumps and underground timber are not removed after planting, most estates which are properly managed become practically free from *Fomes* as they become older. This is due to the preference shown by *Fomes lignosus* for living upon timber in the early stages of decay; as the wood becomes more and more rotten there s less likelihood of *Fomes* growing upon it. *Fomes lignosus* comparatively rarely attacks old rubber trees and the death of many old trees attributed to it is likely to have been really caused by *Ustulina zonata* as described by the writer (5) elsewhere, or by *Sphaerostilbe repens* as will be pointed out later in this paper.

With the general decrease of this disease the fructifications of the fungus are now more rarely seen. The growth of lalang grass in badly kept estates appears to favour the development of fructifications at the base of diseased rubber trees, and upon one low-lying estate seen by me the fruit bodies were produced in abundance along the sides of the drains.

A large number of fructifications were examined by the writer at different times of the year and the large majority of them were found to be sterile. Sections of fructifications which were apparently mature repeatedly failed to show functional basidia. I never succeeded in

obtaining a spore deposit, for even when sections showed that spore-producing basidia were present their number was very small. In view of the apparent paucity of spore production it would be interesting to have fuller information concerning the manner in which the fungus first begins to spread in a young rubber plantation.

3. *Polyporus rugulosus*, Lév.

On several occasions another polyporoid fungus was seen growing at the collar or upon exposed lateral roots of diseased rubber trees and it seemed likely that this fungus was the cause of the disease from which the trees suffered, although inoculation experiments are needed to settle this point definitely. The tissues of the host near the fructifications were invariably decayed, the foliage of the affected trees became thin, and the branches died back after the manner of trees attacked by a slowly growing root parasite. I saw this disease only in trees which were in tapping and it appeared to be more frequent in badly-drained low-lying estates than upon undulating land. One tree severely attacked by this fungus had been previously invaded by white ants.

The fructifications of this fungus are often densely imbricate and, in the aggregate, form large masses several inches across although a single pileus is only an inch or two in diameter. The upper surface is smooth, brownish, and zoned; the under pore-bearing surface is white when young, becoming yellowish brown with age; the pores are minute; the substance of the fructification is thin and although fleshy when young is leathery at maturity. Both in the colour of the pores and in the much thinner substance the fructifications of this fungus differ markedly from *Fomes lignosus*.

I am indebted to Miss Wakefield of the Royal Botanic Gardens, Kew, for kindly identifying this fungus as the *Polyporus rugulosus* of Léveillé. The type specimen of this fungus was obtained from tree trunks in Java and was described by Léveillé in 1844. Saccardo (17) has since placed the fungus in the genus *Fomes*, but on account of the texture of the fungus when young it is preferable to retain the original name. I have been unable to find any previous record of this fungus upon rubber trees.

Pending a further investigation of this fungus, rubber trees affected by it should be treated as for *Fomes lignosus*.

4. *Sphaerostilbe repens,* B. and Br.

During 1914 a considerable number of rubber trees were found to be affected by the fungus *Sphaerostilbe repens* which attacks the root system and advances upwards into the lower part of the trunk. The only previous record of this disease of rubber in Malaya was made by Richards (12) who mentions its occurrence in his report for 1912–13. According to the experience of the present writer this disease is by no means rare in older rubber planted on low-lying land in Malaya; it has been found in Northern Perak, in the district around Teluk Anson, and in the coast lands of Selangor. Only a few trees on undulating land were seen to be affected by it. The disease was first found on rubber estates in Ceylon in 1907 by Petch (10), who states that it is not confined there to the low country.

The foliage of rubber trees affected by *Sphaerostilbe repens* becomes thin and the branches gradually die back. The progress of the fungus being slow, a considerable time may elapse before the whole of the collar or all the lateral roots are affected and the tree succumbs.

If the roots of a tree affected by *Sphaerostilbe repens* are examined, the disease can be readily distinguished from the troubles caused by *Fomes lignosus* and by *Hymenochaete noxia* on account of the absence of external mycelium and by the presence of characteristic mycelial strands or rhizomorphs between the bark and the wood. These strands are usually flattened, are about $\frac{1}{8}$ inch in diameter, and vary in colour according to age from grey to dark brown or black; they are spread irregularly between the bark and the wood and sometimes occur also in the bark (cf. Plate XXXIII, fig. 1).

Even when the rhizomorphs have decayed, their former position is indicated by the presence of corresponding dark lines on the surface of the wood. I did not observe any tendency for these strands to spread independently through the soil. The affected trees were not usually contiguous to one another. The finer mycelium of this fungus permeates all parts of the bark and wood of the affected roots, the wood becoming discoloured and the bark often assuming a bluish purple colour when cut open. The roots of rubber trees affected by *Sphaerostilbe repens* often have a particularly foul smell, but this may be a secondary phenomenon induced by other agents of decay. The fungus advances up the tap root or along the laterals to the collar of the tree. On several occasions I observed it making considerable progress up the trunk, especially in the wood (cf. Plate XXXIV, fig. 3), and in these trees

boring beetles had begun to penetrate the diseased tissues. The shot-hole borer usually attacks portions of rubber trees which have been previously injured by some fungus; the region attacked by these insects is often not affected by a fungus advancing from the root system but in the specimens now referred to there was clearly a connection between the attack of the borers and the advance of *Sphaerostilbe repens* into the trunk. As the writer has pointed out elsewhere (5), rubber trees affected by the fungus *Ustulina zonata* advancing upwards from the collar are sometimes attacked by borers in the same manner.

Most of the trees seen to be affected by *Sphaerostilbe repens* were magnificent specimens of plantation rubber, 15 to 20 years old; the other trees had been recently brought into the tapping round or were ready for tapping.

The fructifications of *Sphaerostilbe repens* are of two kinds, both being minute. The first form to appear is the conidial stage which consists of white or pinkish white blobs about the size of a pin's head borne at the ends of pink stalks which are about $\frac{1}{16}$ to $\frac{1}{8}$ inch long and are hairy when young (cf. Plate XXXIII, fig. 2). This is the *Stilbum* stage and it arises from portions of the host permeated by the fungus or directly from the rhizomorphs; the conidial fructifications have also been seen on clayey soil lying in contact with diseased roots. These reproductive bodies have occasionally been found below the surface of the ground. The spores which arise at the extremities of the *Stilbum* type of fructification are hyaline, oval, and 10–20μ × 5–9μ in size. Another *Stilbum* is an exceedingly common saprophyte on dead portions of rubber trees. This is *Stilbum cinnabarinum*, the conidial stage of *Megalonectria pseudotrichia*, readily distinguishable from the conidial stage of *Sphaerostilbe repens* by its red colour and smaller size. After the formation of conidia the fungus sometimes produces small, dark red perithecia, but I found these only rarely.

Sphaerostilbe repens sometimes lives entirely as a saprophyte on dead plant tissues and doubt has been expressed whether it is really parasitic on the roots of *Hevea*. In rubber trees affected by it that I was able to examine it was undoubtedly advancing into living tissues and therefore acting as a parasite. The actual means by which infection of the roots is effected by this fungus are unknown. The roots may sometimes have been already injured by adverse conditions such as bad drainage, and if the fungus entered such roots it might easily pass thence into healthy tissues.

Pure cultures of the fungus are easily established by sowing conidia upon sterilised blocks of *Hevea* wood or upon potato agar. A white mycelium rapidly develops which assumes first a pink and then a brownish tinge. After a time, sessile aggregations of spores of a yellowish pink colour arise on both media and these are often arranged in concentric zones. These spores are hyaline, oval, and very variable in size, the average limits being 16–20μ × 6–8μ though some are much smaller (cf. Plate XXXIV, fig. 4).

Spherical, thick-walled resting spores 9–10μ in diameter are formed in the hyphae and at the ends of short branches; these spores are brown in colour when mature. On blocks of *Hevea* wood, stalked conidial fructifications often arise similar to those which occur naturally. The mycelium penetrates the middle of these wood blocks, being specially abundant in the vessels and medullary rays. There was no sign of the formation of perithecia in these cultures.

Roots of seedling rubber plants in pots and of 4 year old trees on hilly land were inoculated with pure culture material of the fungus. In some cases the roots were wounded, in others the wood block bearing the mycelium, or the culture on agar, was placed against uninjured tissues. After an interval of nearly five months none of these plants (16 in all) showed signs of infection. This negative result points to the possibility that some, at present unknown, condition which disposes to susceptibility must exist before the fungus can invade the roots of a rubber tree. As pointed out above, bad aeration of the soil consequent on deficient drainage may be a factor in inducing the requisite condition for the fungus to enter.

Rubber trees affected by this fungus should be cut out and burnt. The attack is usually far advanced before the tree is seen to be diseased, hence it is generally not worth while to try to save the tree by excision of the affected parts. There is yet no evidence that the fungus spreads by subterranean strands but neighbouring trees should be examined, and to be on the safe side a trench should be dug around the affected tree at such a distance as to preclude the possibility of underground infection. If it is intended to replant the affected area after an interval, the soil should be deeply dug, all timber removed, and a liberal dressing of lime applied. This disease spreads more slowly than *Fomes lignosus*, and though it is not abundant in Malaya it is probable that the loss of some old rubber trees attributed to *Fomes* was really caused by *Sphaerostilbe repens*.

5. *Hymenochaete noxia*, Berk.

As pointed out by Brooks and Sharples (8) the Brown Root disease of plantation rubber is not of frequent occurrence in Malaya where it is commoner on trees about one-and-a-half or two years old than on mature trees. Petch (10) states that it is probably the commonest root disease of rubber in Ceylon although it causes less damage than *Fomes lignosus*. It is specially prevalent there in old cacao land. Many Malayan estates on the other hand have never been troubled with a case of *Hymenochaete*. As is well known, roots affected by this fungus are invested with masses of soil and small stones which become cemented to the bark. Patches of brown mycelium are frequently found intermixed with the débris on the exterior of the root, hence the popular name of the disease. The fungus does not produce mycelial strands which travel through the soil, so infection must result either through the roots coming into contact with other material containing the fungus or directly from spores. The fructifications of this fungus have not yet been found in Malaya, and Petch (10) states that its fruit-bodies have only occasionally been seen in Ceylon.

Trees affected by *Hymenochaete noxia* should be burnt, and in order to act on the safe side the area around them should be isolated by a trench. If the ground is to be replanted it should be dug over, freed from timber, and well limed.

Although it is customary to refer the brown mycelium associated with this disease in Malaya to *Hymenochaete noxia*, Berk., I have not seen the fructifications of this fungus and therefore cannot confirm its identification.

6. *Ustulina zonata* (Lév.), Sacc.

It has been thought desirable to include in this paper a summary of my investigations upon the root disease of plantation rubber caused by *Ustulina zonata*, a full account of which has appeared elsewhere (5).

This disease had not previously been recorded on rubber in Malaya, but Petch (11) had recently noted its occurrence in Ceylon estates especially where *Hevea* had been planted amongst tea which had been subsequently allowed to die out. In Ceylon this fungus causes a serious root disease of tea.

In Malaya this disease by no means infrequently attacks old rubber trees, although it is only in the few estates where groups of trees have been killed that serious damage has yet been done by this fungus.

The part of the tree chiefly affected is the collar which is usually attacked first on one side only, the bark collapsing. Neighbouring lateral roots and the tap root often become affected in the same manner and in advanced cases the disease may spread up the trunk to a height of three or four feet. If the diseased tissues are exposed, conspicuous black lines are often seen near the limits of the affected parts although these lines are not invariably present. The absence of external mycelium and of rhizomorphic strands between the bark and the wood distinguishes this disease from other well-known root troubles of *Hevea*. As the fungus progresses in the collar and root system of the tree the foliage becomes thin, the branches die back, and the whole tree succumbs unless successfully treated.

The fructifications of the fungus appear as closely adpressed plates, grey brown to blackish in colour, on the collar and exposed lateral roots of affected trees. The fructifications are easily overlooked, especially in wet weather when they become splashed with mud. The conidial stage present in young specimens of the fungus in Ceylon has not yet been found in Malayan specimens although adult fruit bodies are undoubtedly identical. The mature plate-like fructifications which may be several inches across are marked by an irregular and obscurely zoned surface punctured by minute dots. If the grey brown surface of a fruit body is scratched, a black layer is seen which may also become exposed by the natural wearing away of the thin covering. Below this black layer the perithecia are formed from which the spores subsequently exude in black masses.

Wood and bark invaded by the fungus become discoloured. The black lines often found near the margin of the affected tissues are caused by the aggregation and darkening of the hyphae which form a kind of sclerotic plate in the cells of these regions. Pure cultures of the fungus were established on blocks of *Hevea* wood in which similar black lines were formed. It is only when black lines in the tissues are associated with an extensive affection of the collar and root system of the tree that *Ustulina zonata* should be suspected, as two other fungi, *Nummularia pithodes* (B. and Br.), Petch, and a species of *Xylaria* both belonging with *Ustulina zonata* to the Xylariaceae and both common saprophytes on dead rubber wood, produce similar black zones. Inoculations of the roots of seedling *Hevea* plants and of 4 year old trees, just below soil level, with material of the fungus growing in pure culture were followed by the establishment of the fungus in the tissues, some of the seedlings being killed in consequence.

In Malaya it is likely that the fungus often begins to grow on decayed stumps from which it passes to the rubber trees, the fungus spreading from one tree to another by contact of diseased roots with healthy ones. On some of the older estates in which the disease has been found, however, very few stumps remain and it is likely that there are other means of infection. Some of the old trees affected by *Ustulina zonata* had been previously attacked by white ants. White ants frequently invade rubber trees attacked by *Fomes lignosus* and the reverse process may possibly occur in the case of *Ustulina zonata*.

It is important that this disease should be dealt with at an early stage although it is then rather liable to be overlooked. If the condition of the bark on one side of the collar of the tree arouses suspicion it should be examined, and if found to be diseased all discoloured tissues should be cut out and burnt and the exposed surfaces tarred; diseased lateral roots should be destroyed unless they are large, when the unhealthy tissues should be excised. If the fungus has penetrated so far into the tree that it would fall if all the affected tissues were cut out, the tree is doomed, but as the fungus spreads only slowly the tree may be kept in tapping until it ceases to yield latex in paying quantities. In order to act on the safe side, infected areas should be isolated by means of trenches.

7. *Botryodiplodia theobromae,* Pat.

After *Corticium salmonicolor,* this fungus causes the greatest amount of injury to the shoot system of *Hevea* in Malaya. *Botryodiplodia theobromae* may enter the tree in several ways; it may invade young shoots killed by *Gleosporium albo-rubrum* or by *Phyllosticta ramicola*, it may enter branches already attacked by Pink Disease caused by *Corticium salmonicolor,* or it may act as a wound parasite without association with attack by any other fungus. Whatever the mode of entry, *Botryodiplodia theobromae* spreads rapidly downwards in the tissues killing the branches and main stem as it proceeds so that the disease is popularly called "die-back." The fungus usually advances faster in the wood than in the bark, though in some trees attacked during 1914 the reverse was apparently the case.

Petch (10), Richards (12), and Bancroft (1) all point out that *Botryodiplodia theobromae* often attacks groups of rubber trees simultaneously and the same tendency has been noted by the writer. Rubber stumps have been affected by the fungus soon after being planted out though it was not possible to determine the manner of infection.

The only mode of treatment is to cut out and burn all affected parts as soon as the disease is seen. Prompt action is particularly necessary in dealing with this disease on account of the rapidity with which it develops. If an estate is being thinned out, the rubber trees which are discarded should not be allowed to remain lying in the plantation indefinitely as such material offers a good breeding-ground for this fungus.

Many different names have been given to this fungus but *Botryodiplodia theobromae* has the right of priority as far as its common conidial stage is concerned. In 1911 Bancroft (1) described the development of an ascus stage in its life-history. During my residence in Malaya I devoted special attention to trying to find the perithecia described by Bancroft but without success. Branches of *Hevea* attacked by *Botryodiplodia* were kept under conditions favourable for the formation of perithecia but in no case did ascus formation result. As far as I am aware no other observer has found the *Thyridaria* which Bancroft considers is the complete stage of the *Botryodiplodia*, and until confirmation of the presence of a perithecial stage is obtained it seems preferable to retain the name *Botryodiplodia theobromae* for the fungus.

8. *Bark Diseases.*

Diseased bark was frequently seen in rubber trees, but apart from a careful search in vain for the bark canker of Ceylon attributed by Petch (10) to *Phytophthora Faberi* I had no time to investigate troubles of this nature in detail. As soon as the bark of a rubber tree becomes diseased, boring beetles are almost certain to attack the affected tissues. Where boring beetles attack a tree high up there is obviously no connection between their invasion and the action of a root parasite as described above under *Ustulina zonata* and *Sphaerostilbe repens*. I have occasionally seen borers penetrating the laticiferous layer of healthy bark by continued attacks, but usually they can only successfully invade bark which is diseased.

None of the diseased bark examined in Malaya presented the features associated by Petch (10) with the bark disease caused by *Phytophthora Faberi* in Ceylon. Many attempts were made by culture experiments to isolate a *Phytophthora* from bark taken from the junction of healthy and diseased tissues but in place of it some species of *Fusarium* or other hyphomycete was invariably obtained. This, however, is not sufficient evidence to justify the belief that species of *Fusarium* are capable of

causing disease of *Hevea* bark. No mycologist who has resided in Malaya for any considerable period has yet isolated a *Phytophthora* from diseased rubber bark, hence the statement of Rutgers (15) of Java who after a brief visit to the Federated Malay States, and without isolating the supposed causative fungus, announced the presence there of a bark canker caused by *Phytophthora Faberi* cannot be considered conclusive. Until the fungus has been isolated from diseased bark and has successfully infected trees which have been inoculated it seems premature to say that the bark canker caused by *Phytophthora Faberi* occurs in Malaya.

Rutgers and Arens (16) consider that the burrs on rubber trees are often due to *Phytophthora Faberi*, a view for which the writer does not think sufficient evidence has yet been brought forward.

9. *Burrs.*

There are two kinds of burrs on rubber trees, one consisting of small, pea-like swellings in the bark, the other being irregular woody growths extremely variable in size which arise both on tapped and untapped surfaces though chiefly on the former. The pea-like nodules can be cut out with a knife as they are somewhat easily separated from the surrounding tissues. This kind of burr is of little economic importance. The irregularly shaped burrs on the other hand are of considerable economic importance as they seriously incommode tapping operations and may even render the renewed bark incapable of being tapped effectively. These burrs are specially abundant on trees that were overtapped during the boom of 1910.

Apart from Rutgers and Arens (16), mycologists are in agreement that burrs on rubber trees are not due to the action of parasitic organisms but are caused by some physiological disturbance.

Bateson (3) attributes the formation of the "pea" type of burr, which often occurs on the sites of old leaf scars, to the stimulus set up by the coagulation of latex in the tubes which formerly passed out to the leaves with the vascular bundles. Richards and Sutcliffe (13) put forward the view that the large, irregular burrs are likewise caused by the stimulus on the surrounding tissues set up by the coagulation of latex in tubes which belong to the laticiferous system of the stem. There is good evidence for both these views. A small percentage of burrs is doubtless due to wounds made in the wood through bad tapping.

With the conservative and more careful methods of tapping in

general use at the present time, burrs will probably be less troublesome in the future than in the past. The larger type of burr is difficult to treat but good results appear to have been obtained on some estates by using a plane to make the surface smooth after removing these irregular excrescences.

10. *Thread Blight.*

A white thread blight is of common occurrence on rubber trees in Malaya but it causes little harm. The mycelial strands of this fungus vary considerably in size and run long distances over the branches, matting the finer twigs and leaves together and sometimes enveloping the leaves with a fine felt of hyphae causing them to die. The fungus is conspicuous and should be cut out before it has had time to do any considerable harm. This white thread blight is very variable in character and it is possible that more than one species of fungus is involved. Thread blights rarely fructify and there is at present only one record of a fruiting stage in Malaya observed by Richards (12) who sent the fungus to England for identification. It was named *Cyphella Heveae* by Massee and is thus a member of the Thelephoraceae. Thread blight is of common occurrence on other cultivated trees in Malaya.

11. *Phyllosticta ramicola,* Petch.

This fungus affects young green twigs of *Hevea brasiliensis* and sometimes affords opportunity for the entrance of *Botryodiplodia theobromae* as pointed out by Richards (12) and Bancroft (1). It occurs more frequently on trees one to two years of age than on older ones and is usually most abundant towards the end of the year when the rains are heaviest. The fungus generally enters the twig at one or more of the leaf axils 6 to 18 inches below the apex, the fungus probably beginning the attack in the leaf axils because moisture is retained here better than elsewhere. The first sign of its development is the appearance of small brown patches which spread upwards and downwards causing first a blackish and then a brownish discoloration of the stem. At the same time enormous numbers of pycnidia scarcely visible to the naked eye are formed on the discoloured parts. The disease spreads rapidly downwards and as much as 3 feet of the stem may be killed in the course of a week. The extremities of the affected twigs, which are often not invaded by the fungus, die in consequence of the

failure of the water supply caused by the presence of the fungus below. On one low-lying part of an estate an outbreak of this disease was almost epidemic in character, more than 200 trees, one to two years old, growing on peaty soil being affected together. Trees of the same age on higher land with better soil remained unaffected. Poor drainage and a peaty soil often check the growth of rubber trees which appear generally to be more subject to disease under these conditions, possibly on account of a lessened resistance to parasitic organisms.

Branches affected by this fungus should be cut out and all diseased portions burnt. If an attack on young trees is observed in an early stage the trees which are still healthy should be sprayed at intervals with Bordeaux mixture.

A *Phyllosticta* was also sometimes found on the margins of rubber leaves and inoculations showed that it could act as a weak parasite causing a brown discoloration of the leaves from the margin inwards. The spores of this *Phyllosticta* appeared to be identical with those of *Phyllosticta ramicola* but it was not possible to carry out comparative cultures to test this.

12. *Gleosporium albo-rubrum*, Petch.

Petch (10) first described this fungus as causing a die-back of the green shoots of *Hevea* in Ceylon which was often the forerunner of attack of the woody parts by *Botryodiplodia theobromae*. The fungus plays the same rôle in Malaya and what is apparently the same fungus often affects young leaves also. Both upon the young stem and upon the leaves the pustules of this fungus are pink in colour, the individual spores being hyaline and $14\text{–}20\mu \times 4\mu$ in size. On young stems of *Hevea* I have sometimes seen this fungus intimately mixed with *Phyllosticta ramicola*. Where *Gleosporium albo-rubrum* occurs on recently unfolded rubber leaves it causes them to shrivel from the margin and fall rapidly from the tree. On a few mature trees growing in low-lying land I have seen this fungus so abundant at the time of unfolding of the leaves after "wintering" that the ground below was thickly carpeted with the leaves which had been shed. Leaves of *Hevea brasiliensis* at the time of unfolding are of delicate texture and are much less resistant to fungoid attack than when fully developed. This was the only indication I saw of any present danger of a serious leaf parasite of plantation rubber.

13. *Cephaleuros* sp.

Although this alga is of no economic importance on rubber as is *Cephaleuros* on tea it is interesting to note that an organism of this nature can penetrate the leaves of *Hevea*, on which it is often found in the form of small brown spots more especially on the under-surface. Filaments of the alga grow out from these spots and terminate in groups of sporangia as shown in Plate XXXV, fig. 5. This alga is of common occurrence on the leaves of other plants in Malaya and is specially abundant on clove in which Ridley (14) states that it causes a serious disease.

14. *Loranthus* spp.

As pointed out by the writer (6) in a Malayan publication, two kinds of *Loranthus* occurred as semi-parasites on the branches of old rubber trees in a few estates in Negri Sembilan and in one or two areas some damage was being done by them. Bateson (4) has also recorded the presence of a species of *Loranthus* on rubber in Pahang. In the Negri Sembilan estates, portions of branches beyond the place of attachment of the parasites were often killed. The trees most severely affected were generally in poor condition, being badly burred and having been overtapped some years before. The foliage was thin and this circumstance probably assisted the parasites to become established, for in trees possessing a vigorous leaf canopy the shade cast by the crown tends to prevent the establishment of these troublesome plants. The development of *Loranthus* on a rubber tree is a drain upon its resources, and if such "mistletoes" are allowed to develop with impunity the tree will become impoverished, just as apple trees in some parts of England are weakened by the unchecked development of *Viscum album*.

All branches of rubber trees affected by these growths should be cut back well beyond the region to which the parasite extends.

Various species of *Loranthus* are of common occurrence in Malaya on many kinds of trees and shrubs. One of the species found on rubber trees grows frequently on *Melastoma malabathricum*, which is one of the commonest wayside shrubs in Malaya. The species of *Loranthus* seen on rubber trees are provided with runner-like processes which creep along the branches of the host giving off suckers here and there which form the means of attachment and the channels by which food substances are obtained. Some of the suckers become much swollen

and the stem of the host in the immediate vicinity is abnormally developed, the whole producing a large knob of hypertrophied tissue. Other suckers which are much closer together than the former kind are not associated with any marked hypertrophy of the host.

The leaves of these species of *Loranthus* are extremely variable in size and shape. Plate XXXV, figs. 6 and 7 are photographs of one of the kinds of *Loranthus* which affects rubber trees showing the creeping stems and the hypertrophied tissue where the parasite penetrates the host deeply.

In conclusion I wish to express my hearty thanks to Mr F. de la Mare Norris of the Agricultural Department, Federated Malay States, for permission to reproduce his drawings of *Sphaerostilbe repens* in Plate XXXIII, figs. 1 and 2, and for making the drawings for Plate XXXIV, fig. 4 and Plate XXXV, fig. 5. I am also indebted to Mr A. Sharples of the same department for taking for me the photographs used in Plate XXXV, figs. 6 and 7.

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× 1.

Fig. 1

× 30 diam.

Fig. 2

Sphaerostilbe repens, B. and Br.

Diseases of Plantation Rubber

Fig. 3

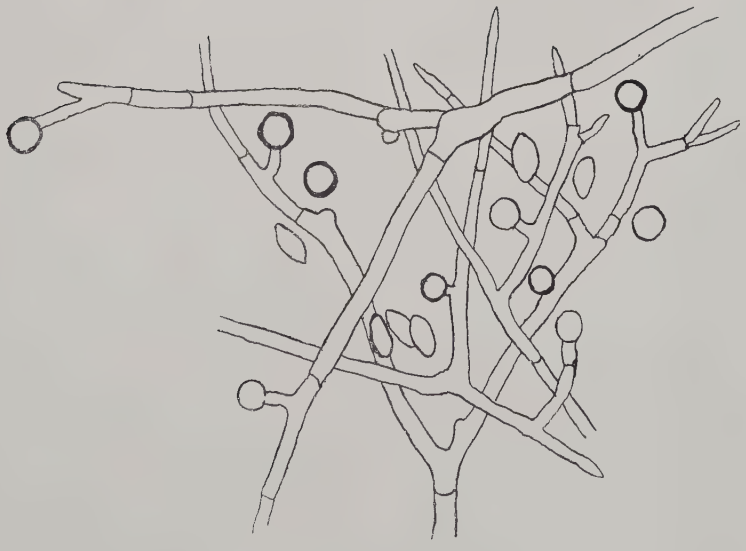

Fig. 4

Diseases of Plantation Rubber

Fig. 5

Fig. 6

Fig. 7

Diseases of Plantation Rubber

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EXPLANATION OF PLATES.

PLATE XXXIII.

Fig. 1. Root of rubber tree with strands and conidial fructifications of *Sphaerostilbe repens*. Natural size. (Water-colour sketch by Mr F. de la Mare Norris.)

Fig. 2. *Stilbum* stage of *Sphaerostilbe repens*. ×30. (Water-colour sketch by Mr F. de la Mare Norris.)

PLATE XXXIV.

Fig. 3. Photograph of rubber tree attacked by *Sphaerostilbe repens* and by boring beetles. The bark has been removed to show the upward extension of diseased wood (*d*) from the root system.

Fig. 4. Conidia of *Sphaerostilbe repens* formed in a pure culture on *Hevea* wood. Some spores are thick-walled. ×450.

PLATE XXXV.

Fig. 5. *Cephaleuros* sp. Material growing on a clove leaf. The species on rubber leaves is apparently the same. ×600.

Figs. 6 and 7. Photographs of branches of rubber trees attacked by *Loranthus*. + is a branch of *Hevea*, *p* is a part of the parasite, *h* in Fig. 7 is a mass of hypertrophied tissue belonging chiefly to the host.

NOTE ON DR J. SMOLÁK'S PAPER "A CONTRIBUTION TO OUR KNOWLEDGE OF SILVER-LEAF DISEASE."

(*Annals of Applied Biology*, July, 1915.)

In reading Dr Smolák's interesting paper I gather that he does not fully understand my views on Silver-leaf disease. As his presentation of my views may lead to misunderstanding, I wish to take this opportunity of correcting any misapprehension that may arise.

On page 154 of his paper the following statement occurs: "According to the investigations of .... Brooks the basidiomycete *Stereum purpureum* is the cause of Silver-leaf disease as was shown by successful inoculation experiments," the investigations referred to being those described in the *Journal of Agricultural Science* for June, 1913. This statement does not agree with my own deductions from these investigations which were expressed in that paper in the following words:

> "In a previous paper (*Journal of Agricultural Science*, 1911) .....I pointed out it would be rash to say that *Stereum purpureum* was the *only* cause of Silver-leaf. Recent investigations have strengthened this view, for specimens of silvered foliage have been seen which I am unable to attribute to the action of *Stereum purpureum*" (page 288).
>
> "....silvering of foliage is a widespread phenomenon which is probably induced by various means, the chief one of which in the fruit-growing districts of this country being the fungus *Stereum purpureum*" (page 288).
>
> "It has been shown that Silver-leaf is a pathological condition of widespread distribution, the chief cause of the malady in the fruit plantations of this country being the fungus *Stereum purpureum*. ..... Examples of silvered foliage have, however, come under observation which, in my opinion, cannot be attributed to the action of *Stereum purpureum*. It is unlikely that the silvering of the leaves of seedling Plums and of such a plant as the White

Dead Nettle is caused by this fungus. I look upon Silver-leaf as a general pathological phenomenon which may be caused in various ways, although at present only one of these agents, the fungus *Stereum purpureum*, is known with certainty" (page 306).

These extracts show a considerable divergence between Dr Smolák's statement quoted above and the views concerning Silver-leaf enunciated by me. The same opinions on the disease were also expressed by me in an article that appeared in the Journal of the Board of Agriculture for November 1913.

On page 155 of his paper Dr Smolák after quoting descriptions of two cases in which I pointed out there was no connection between silvering and *Stereum purpureum* or *vice versâ* says: "Surely in the light of this evidence it is not possible to believe that *Stereum purpureum* is the sole cause of the disease!" The above quotations from my paper show that this is the substance of the view expressed by me in 1913 though Dr Smolák makes no mention of this fact.

F. T. BROOKS.

Cambridge,
August 18*th*, 1915.

SPRAYING FOR APPLE SUCKER (*PSYLLA MALI*).

By F. R. PETHERBRIDGE, M.A.

(*School of Agriculture, Cambridge University.*)

It is a common practice among fruitgrowers to spray their apple trees at the time when the buds are bursting, in order to check the ravages of the apple sucker. It is supposed that the washes applied prevent the eggs from hatching. Some experiments[1] were carried out in 1914 by the writer to try and find out how much good the various washes did in this connection.

The following experiments are a continuation of this work in more detail.

The experiments were carried out in one of Messrs Chivers and Sons' orchards. Each plot contained ten apple trees alternated with plum trees, and was separated from its neighbour by a row of plum trees. The trees were about twenty years old and all of the variety Keswick Codling.

At the end of February the number of apparently fertile apple sucker eggs were counted on certain twigs. A twig was chosen on each of three trees on every plot. The twigs were as similar as possible and were situated on the outside of the trees in order to prevent insects from falling from above. They were thickly covered with eggs, each carrying about 500.

A high pressure spraying machine was used for making the applications, and special care was taken to cover all the eggs which had been counted. It should be noted that on many of the trees, although carefully sprayed, about 20 % of the eggs were untouched by the spray. Observations were also made in the orchards of other growers, and it was found that a considerable proportion of the eggs are not covered by the spray fluids used.

[1] *Journ. Board of Agric.* Jan. 1915.

In these experiments the average amount of fluid applied to each tree was about six gallons.

Two plots were used for each mixture. The first application was made early in March just as the buds showed signs of swelling, and the second application was made a fortnight later just as the leaves were beginning to show.

Plots *B, D, F, I, K,* and *M* were sprayed on March 4th and 5th in fine weather, and rain fell on March 6th.

Plots *C, E, G, J, L,* and *N* were sprayed on March 18th.

There was a little snow falling while these plots were being sprayed but not sufficient to prevent the sprays from drying on the trees. After the spraying there was a heavy fall of snow which washed off some of the spray.

After spraying a band of Tanglefoot was placed round each of the 42 twigs in order to prevent any young suckers from crawling on or off the shoots.

Twigs were cut on March 13th and kept in the Laboratory and on these the suckers began to hatch on March 20th. On the plots they did not begin to hatch until April 8th. This lateness of hatching was probably due to the cold nights experienced after the second spraying as the buds were sufficiently advanced to provide nourishment for the suckers on March 18th, and it was for this reason that the second spraying was done earlier than was originally intended.

Maximum and Minimum Temperatures taken on the Experimental Plots.

	Max.	Min.		Max.	Min.
March 15	50	40	March 26	44	29
16	53	36	27	43	25
17	49	32	28	44	21
18	50	40	29	41	22
19	41	24	30	46	22
20	43	26	31	48	27
21	53	30	April 5	59	28
22	47	25	6	56	30
23	55	41	7	55	43
24	60	34	8	55	34
25	60	38			

The suckers continued to hatch until April 28th. The number of suckers which hatched were counted on April 29th to May 6th.

The following table gives the treatment, the number of eggs on each twig and the numbers which hatched.

Plot	Treatment	Twig	Number of eggs on twig	Number hatched	Percentage hatched	Mean
		A 1	466	424	90	
A	Untreated	*A* 2	443	320	72	83 %
		A 3	482	416	86	
		B 1	610	334	55	
B	Sprayed on March 5, 1915, with: lime ... 200 lbs, water ... 100 gals } self-boiled	*B* 2	461	271	59	57 %
		B 3	344	197	57	
C	Sprayed on March 18, 1915 Mixture as *B*	*C* 1	493	273	55	
		C 2	599	409	66	62 %
		C 3	496	325	65	
		D 1	511	122	24	
D	Sprayed on March 5, 1915, with: lime ... 150 lbs, salt ... 30 lbs, water ... 100 gals } self-boiled	*D* 2	632	236	37	27 %
		D 3	678	138	20	
E	Sprayed on March 18, 1915 Mixture as *D*	*E* 1	511	289	57	
		E 2	467	407	87	68 %
		E 3	442	262	59	
		F 1	468	437	93	
F	Sprayed on March 4, 1915, with: lime ... 40 lbs, sulphur... 24 lbs, water ... 100 gals } boiled for 1 hour	*F* 2	457	298	65	76 %
		F 3	489	349	71	
G	Sprayed on March 18, 1915 Mixture as *F*	*G* 1	557	274	49	
		G 2	516	347	67	61 %
		G 3	338	222	66	
		H 1	562	404	72	
H	Untreated	*H* 2	491	482	98	88 %
		H 3	449	428	95	
I	Sprayed on March 4, 1915, with: commercial lime sulphur wash	*I* 1	465	408	88	
		I 2	554	544	98	87 %
		I 3	595	471	75	
J	Sprayed on March 18, 1915 Mixture as *I*	*J* 1	486	434	89	
		J 2	498	311	62	83 %
		J 3	502	488	97	
		K 1	424	411	97	
K	Sprayed on March 4, 1915, with: lime ... 40 lbs, salt ... 12 lbs, sulphur... 24 lbs, water ... 100 gals } boiled for 1 hour	*K* 2	483	464	96	84 %
		K 3	528	309	59	
L	Sprayed on March 18, 1915 Mixture as *K*	*L* 1	280	266	95	
		L 2	472	452	95	90 %
		L 3	643	522	81	
		M 1	507	431	85	
M	Sprayed on March 5, 1915, with: lime ... 12 lbs, sulphur... 24 lbs, water ... 100 gals } boiled for 1 hour	*M* 2	537	363	68	82 %
		M 3	541	503	93	
N	Sprayed on March 18, 1915 Mixture as *M*	*N* 1	561	537	95	
		N 2	492	475	96	93 %
		N 3	449	402	89	

The above results although showing large variations for the same treatment give some idea as to the amount of suckers which are prevented

from hatching by spraying at this time of the year. They indicate that the various kinds of lime-sulphur and lime-salt and sulphur are not effective in keeping down apple sucker; also that lime wash is partially effective and lime and salt wash still more effective. It is difficult to explain why the lime-salt wash which was applied on March 5th (Plot *D*) should be more effective than that applied on March 18th (Plot *E*) unless the heavy fall of snow which followed the spraying washed off some of the deposit.

Last year lime-salt and sulphur proved more effective than lime or lime and salt. The apple suckers which hatched out were so numerous that they seriously affected the crop on all the plots, and judging from the whole plots no very marked benefit as indicated by the above figures could be seen on Plot *D*.

It is possible that more good might have been done by a later application, but the buds were shooting when Plots *C, E, G, J, L,* and *N* were sprayed, and a later application last season injured the young foliage.

In the Active Season.

In this experiment most of the ordinary washes used against apple sucker were tried. The plots were similar to those in the above experiments.

The sprays were applied on May 7th, 1915, and at this time the flower trusses were opened, but the flowers themselves had not opened.

Plot *O*[1].	Soft soap	10 lbs
	Creosote oil (crude commercial)...	1 quart
	Water	100 gallons.

This wash was effective in killing the suckers but caused scorching of the leaves and cannot be recommended for Keswick Codlins.

Plot *P*.	Soft soap	10 lbs
	Nicotine (98 %)	8 ozs
	Water	100 gallons.

This wash penetrated well and was very effective in killing the suckers.

Plot *Q*.	Agricultural treacle	6 lbs
	Nicotine	8 ozs
	Water	100 gallons.

This wash penetrated well and was very effective in killing the suckers.

[1] Recommended by Awati, *Ann. App. Biol.* Vol. 1, 1914–15.

Plot *R.*	Soft soap	10 lbs
	Paraffin	2 gallons
	Water	100 gallons.

Almost as effective as *Q.*

Plot *S.*	Soft soap	10 lbs
	Quassia	10 lbs
	Water	100 gallons.

Almost as effective as *R.*

Plot *T.*	Soft soap	10 lbs
	Water	100 gallons.

Not so many suckers killed.

In this experiment the suckers were so numerous that these sprayings had no very marked effect on the yield. Most of the trusses fell off as a result of the injury done to them by the suckers in the young stages. This shows the necessity for preventing the suckers from hatching.

Conclusions.

These experiments indicate that lime and salt may be effective in preventing a large proportion of apple sucker eggs from hatching. Lime wash was also fairly effective.

Soft soap and nicotine, or treacle and nicotine, were the most effective after the suckers had hatched.

Spraying to prevent the eggs from hatching is not sufficient to keep this pest under control, but should be followed by an application of nicotine and soft soap, or treacle and nicotine, to kill those which have hatched.

My thanks are due to Messrs Chivers and Sons for their kind permission to use their orchard, and for bearing the expenses of the experiments.

ON THE BIOLOGY AND ECONOMIC SIGNIFICANCE OF *TIPULA PALUDOSA*.

By JOHN RENNIE, D.Sc., F.R.S.E.

(*North of Scotland College of Agriculture.*)

Part I. Mating and Oviposition.

(With Plate XXXVI.)

In the course of the summers of 1913 and 1914 the mating and oviposition of *Tipula paludosa* formed the subject of special study both in the field and in laboratory experiments. As far as the writer knows no account of the sexual behaviour of this species is on record, at all events in detail. The points of special interest which have been made out are summarised in the present paper; the observations of the first season have been confirmed in the second.

Mating.

The earliest occasion in a season upon which mating was observed in progress was 20th June, 1914. This was in a field cage in which the flies had hatched out naturally. In the previous year, when a closer watch was kept, and the flies were reared in captivity and probably hatched earlier than in the field, the date was actually later, viz. 4th July. It may here be mentioned that, as detailed in a subsequent paper, there is only one generation of this species in the year in the north of Scotland. In the south of Britain it is held that two generations occur.

The flies experimented with were reared from larvae which had been kept in field and laboratory cages. The pupae were collected and transferred to small vessels about the size of ordinary flower pots

The work recorded in this and subsequent papers has been carried out with the aid of grants from the Board of Agriculture for Scotland.

containing soil covered with small pieces of turf. On the top of the turf was placed a glass cylinder about 9 inches high and $3\frac{1}{2}$ inches in diameter. In some instances, lamp chimneys with nearly twice this width at their base were used. These were about 12 inches high but narrowed to about 2 inches diameter at the top. The vessel was kept closed by a piece of light cardboard placed upon the opening at the top. There were never more than two or three adult insects confined in these simple cages; they appeared quite comfortable and lived in most instances about a week, in some cases as long as eleven days.

The following observations are typical of the general results obtained and will serve as descriptive of the mating habits of these insects under the conditions which have been specified.

On the 5th of July, 1913 at 11.15 a.m. a pair of crane flies of the species *T. paludosa*, here referred to as *M* 1 and *F* 1, was found *in coitu* in one of the larvae rearing cages. They were removed without being separated to one of the glass observation vessels and watched until 1 p.m. at which time they still remained united. At 1.45 p.m. they were found to have separated. They were the sole occupants of this particular cage. This is referred to as Mating (*M*1 + *F*1)1.

At 2.30 p.m. on the same day they again spontaneously effected coitus, remaining attached until 3.30 p.m. Mating (*M*1 + *F*1)2.

At 4.15 p.m. on the same day mating was again accomplished between this pair. Coitus lasted until 5.23 p.m. Mating (*M*1 + *F*1)3.

The same evening these flies were placed together upon a small enclosed grass plot. For a short time they remained indifferent to each other, and the female commenced oviposition.

A second female, *F* 2, newly hatched, was placed beside them and almost immediately the male flew towards her and, after a short struggle in which some of the legs of the female were broken off, coitus was effected. Mating (*M*1 + *F*2)1.

At 10.20 a.m. on the following day a newly hatched male, *M* 2, was introduced to the vessel beside *F* 1, who had as already noted been ovipositing. Union was immediately effected. At 12 noon they still remained *in coitu*, and at this hour they were taken apart and placed in different vessels. Mating (*M*2 + *F*1)1.

At 12.15 p.m. *M* 1 was once more placed beside *F* 1. At 2.40 they had taken no notice of each other. They were now disturbed and made to fly about the cage. Upon coming into proximity they mated. Mating (*M*1 + *F*1)4.

At 4.30 they were found to have separated. They were left together overnight.

On the morning of the 7th, this female *F* 1 was removed to another vessel beside a male, *M* 5, hatched overnight. He flew at her instantly on her arrival and in a few seconds mating was effected, 9.55 a.m. At 11.20 a.m. they were found to have separated. Mating (*M* 5 + *F* 1) 1.

F 1 was now placed in a small glass vessel over some moist cotton wool. Up till 6.35 oviposition had not taken place under these conditions. At this hour she was placed over soil to see if this would now supply the stimulus. The result was negative. This female, however, was known to have oviposited previously, and at this stage she had lost the full-bodied appearance of the unmated female and was quite slender in form.

On the 9th, *F* 1 was placed with another male, *M* 6, but no union took place. From this date she was kept in the company of a male until she died. This occurred upon the 16th and meantime no further mating had been effected in her case. Reviewing the facts regarding her, it is noted that between the morning of the 5th and the morning of the 7th she mated at least six times, and with three different males. She lived 11 days in captivity.

The male *M* 1, as has already been recorded in the account of the behaviour of *F* 1, mated with her four times in the course of two days. He also mated with another, *F* 2, within a short time of her hatching. This took place at 7.10 p.m. on the 6th July. At 9.15 they were still mated, and on the following morning they were again found *in coitu*.

At 10.35 upon the morning of the 6th this male was introduced to a vessel in which there were already three females and one male. He at once flew amongst these and in a few seconds became coupled to a hitherto unmated female *F* 3. They remained *in coitu* until 12.15 when they separated. Subsequently as recorded for the female, *F* 1, he paired with her at 2.40 p.m. of the same day.

No further opportunities for mating were given to this male until the 9th (four days after he was first found mated), on which day he was placed with a newly hatched female *F* 9 at 11 a.m. They were left together until 3.20 p.m. but coitus did not take place. He mated at least seven times in the course of two days. He died upon the 12th, having lived seven days.

A number of similar experiments were performed and always with consistent results. Recently hatched insects paired most readily, and

most were ready upon opportunity to pair a number of times. The following are additional notes.

F 12 placed in vessel with males, *M* 11, *M* 12, and *M* 13. *M* 11 attempted coitus and failed. *M* 12 succeeded. *M* 12 subsequently mated with *F* 13.

F 16, *F* 17, *F* 18 placed in a vessel containing a crowd of males. The males immediately flew to them and in a few seconds all three females were mated.

F 20 and *M* 17, both hatched on the morning of 18th July. They mated at 10.30 a.m. During the day she oviposited. *F* 21 and *M* 18, hatched later in the day, both mated. *F* 21 had defective wings. These four insects were placed together. Both pairs mated again in the evening. On the following evening *F* 20 mated once more with either *M* 17 or *M* 18. By this time she had become quite slender, and had evidently oviposited freely.

F 25, hatched on 28th July. Placed with *M* 24. Mated and oviposited. On the 30th she was placed with 14 males captured in the open. There was much commotion on her arrival and in a short time one of the males succeeded in mating with her.

F 27, hatched 6th August. Dropped into vessel containing *M* 24, *M* 25, and others. An immediate contest for her took place; mating successful.

F 28. Placed with the foregoing, with same result. The males immediately surrounded her, and mating was effected in the course of a few seconds.

In seeking to effect coitus, the male alights above the female and prevents her escape, should she attempt it, by intermingling of their limbs. Meantime his abdomen, which is now markedly upturned at the tip, is passed below that of his mate. The widely gaping claspers seize her on the thickened basal part of the ovipositor and the hold having been made secure the pair rest a few moments in this position. The male, now releasing his hold by the limbs, turns round so as to face in the opposite direction from the female. This is the position maintained until separation takes place. Sometimes the wings are folded, but more usually in both sexes they are extended. During coitus the antennae of the male continue in active backward and forward quivering motion. In his case too, the halteres quiver periodically in spasms of about a second's duration and at frequent but irregular intervals. This last

feature was constantly to be observed and appeared to be directly associated with the sexual activity in progress. After attachment contractile movements are observable at the tips of both abdomens for a short period; subsequently the female rests absolutely passive. Cf. Plate XXXVI.

Oviposition.

This may take place quite early after mating. *F* 1 after having mated three times upon the 5th July commenced oviposition in the evening. *F* 2 mated on the 5th was watched in the process of egg laying on the morning of the 6th. Another female, *F* 5, hatched at 9.50 a.m. upon the 7th and mated immediately afterwards. She mated again with the same male *M* 12 in the afternoon. They separated at 4.20 and at 5.27 she was watched engaged in oviposition, and her eggs were collected when she had moved away.

Curtis (*Farm Insects*, p. 445) says: "the eggs are laid by the females as they fly or when they rest among the herbage and are propelled as from a pop-gun." So far I have not been able to witness this propulsion of the eggs while the insects were on the wing, but it will be understood that the conditions of my earlier experiments were not favourable to this method.

I have repeatedly watched the process amongst grasses. The female stands in a vertical position with the ovipositor pushed well down and into the soil if she can reach it. Sometimes a backward and forward screwing motion of the body is indulged in so that the ovipositor is bored well into the ground. Spasmodic jerks of the hinder part of the abdomen indicate the expulsion of the eggs one by one. After a few minutes she moves along a little way and the process is repeated. About half-a-dozen eggs may be deposited at the same spot, frequently fewer. In one case I was able on lifting a female, not actually ovipositing but exhibiting spasmodic movements of the ovipositor, to get her to lay an egg upon a card in my hand.

Newly hatched females are bulky in appearance at the anterior end of the abdomen. After oviposition they become slender. In this way one can tell whether a female has oviposited or not, though not generally whether the process is completed or not. The eggs in the newly hatched female mostly show black in colour through the skin and are shelled before fertilization. Advanced female pupae have the abdomen filled with the ovaries which are of a pale salmon pink

colour. Dissection of females some time after oviposition shows that all the ova are not mature at hatching but that there is at least a second batch of eggs. Females captured in the open which are slender bodied, *i.e.* which show signs of having oviposited, have small pear-shaped ovaries occupying the posterior part of the abdominal cavity. The eggs in these may be well-developed and of the typical shape as when mature, but of the pale salmon colour. This suggests that females having oviposited may continue to live and to produce a fresh race of ova. This second lot of ova is not merely mature at hatching but without shells: they increase in size during the adult period. A female, *F* 22, hatched on the evening of the 20th July, and which had been mated and had oviposited, died on the 26th. Dissection showed that all the black shelled ova had been laid, and that the ovaries were small in size and confined to the hinder part of the abdomen. In this case, however, the individual ova were much smaller and had much less yolk than was found in the fly captured in the open and which was therefore presumably older. The question of the length of life of individual crane flies has not so far been settled.

Experiments were performed to test the degree of stimulus needed for the act of oviposition. Flies which had been mated and were placed upon cotton wool did not oviposit. Also when the wool was placed upon a layer of soil, they still failed to respond. Only in a few cases were eggs laid upon bare soil, whilst amongst herbage they were deposited readily. Although crane flies are known to oviposit usually in grass, it was found that they may do so in standing corn also.

The flies kept in captivity were not fed. They usually had access to growing grasses, and to soil, both of which were watered. They were observed licking at moist soil and at the wet sides of the glass vessels in which they were confined.

EXPLANATION OF PLATE XXXVI.

View of *Tipula paludosa* in coitu. The halteres are not visible owing to their vibratory movements.

Mating of *Tipula paludosa*

SOME EAST AFRICAN INSECTS OF ECONOMIC IMPORTANCE.

By R. H. DEAKIN, M.Sc.,

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The economic entomologist in East Africa has many duties to attend to, and the time he devotes to research on insect life-histories (his real object) is often very interrupted. The following notes, being some of the results of intermittent research, during one-and-a-half years residence in the E. A. P., without arriving at any important conclusions, do at least, I think, throw some new light on the problems concerned.

Locusts. Little attention in the past has been paid to locusts as it is only at long intervals that they have caused damage. Natives of various tribes speak of bygone years when locusts were very destructive, but native memory for dates is rather uncertain. During the first five months of 1914 unusual swarms of the adult locust, *Schistocerca peregrina*, and in places, hoppers, appeared throughout the Protectorate, not only in the areas of low rainfall of the N. and S.E. but in the better watered regions around Nairobi, Naivasha, Nakura, the Uasin Gishu and also near Lake Victoria. The damage done was small, only the eating of the tops of a few coffee bushes and some mealies, etc., being recorded: there appeared to be everywhere a sufficient natural supply of food. I was unable, during a journey which I undertook for the purpose, to obtain evidence showing that these locusts had oviposited in any of the areas mentioned. I concluded that they must have proceeded to more arid steppe-like regions for this purpose. Rainfall statistics threw no light on a belief which I entertained that this was an exceptional year of drought in the home of the locusts—wherever this may be. Some facts relating to the life-history of this locust have been worked out in German East Africa, but the questions "When will they come?" and "Why do they come?" are yet to be definitely ascertained. Nor is this a question of secondary

importance to the Protectorate, in view of the fact that there is an ever-increasing area of the country under valuable crops.

Pests attacking Coffee. One of the greatest insect enemies which the coffee-grower in the E. A. P. will have to face in the future is *Antestia variegata*. German East African authorities believe that this extremely active plant-bug can be combated with contact sprays. My investigations were tried in another direction and with some success. Where the occurrence of the insect has been noticed by planters from year to year, it has been found that its activity grows and wanes successively. Quite accidentally I discovered that the increase in number of the bugs is very largely governed by a Chalcid egg parasite. My investigations were interrupted by the war, but were sufficient to prove the importance of this control. The groups of Antestia eggs are laid both on the leaves of the coffee bushes and also very largely on the dead leaves, twigs, etc., which accumulate under the bushes. One Chalcid egg is laid in each Antestia egg and the degree of parasitism is often greater than 50 % of the total number of eggs. The shells of eggs which have been parasitized are easily recognized by their black appearance and by the jagged hole by which the parasite emerged. The Antestia eggs which are laid on the dead leaves below are freer from parasites, possibly because they are more difficult to find by the Chalcids. In the plantation in which my investigation was carried out the eggs laid actually on the coffee bushes were parasitized almost to extinction. I suggest it might be possible to collect the dead leaves, etc., beneath the bushes, to place them in receptacles and, whilst allowing the parasites to escape, to prevent the young bugs from leaving by means of a smear of castor oil and resin tanglefoot. The damage caused by Antestia to coffee trees, by piercing the unripe berries and especially by the production of adventitious shoots, through the killing back of the apical buds, thus complicating pruning to a fearful extent, may be very severe. When the parasite occurs, efforts should be made, by its study, to increase its intensity of action, and where it does not occur to introduce it. The parasite has been sent to Mr G. A. K. Marshall of the British Museum for identification.

Scale Insects on Coffee. *Lecanium* (*Saissetia*) *nigrum*, Niet., was found at an altitude of 6000 ft. Many individuals were parasitized.

I have examined specimens of the common scale on coffee from many parts of the Protectorate, but have found no specimens of *Lecanium viride*—all proving to be the closely related *L. africanum*.

Cut Worms and Coffee. The common cut worm is *Euxoa segetum*.

If the total loss to the planters, caused by this insect attacking young coffee, could be assessed, I think the result would be startling. The ring-barked tree may not die till months later, hence there is an additional loss of time. Many people believe in the growing of maize between the coffee and even in leaving weeds as food for the caterpillars; they forget that by so doing they are encouraging the moths to lay eggs in their plantations. The remedy lies in clean cultivation and the intelligent use of poison bait. As soon as the value of these methods is emphasized by those in authority the loss will be considerably reduced.

Pests attacking Citrus. Citriculture should be an important and remunerative occupation in B.E.A. in the future and the importance of insects in this connection must not be forgotten.

Argyroploce leucotreta, Meyr. This is also a pest in S. Rhodesia. It causes extensive damage to the orange crop at the experimental farm at Kabete, B.E.A. The caterpillar, which feeds inside and ruins partly ripe oranges, pupates just beneath the surface of the soil. The eggs are small, flat and scale-like, and are, I believe, laid on the fruit. Experimental spraying of the unripe fruit with lead chromate was not a success, sprayed trees suffering equally with the controls. This was found to be because the minute caterpillar on boring through the surface of the fruit appears to be in a great hurry and merely bites its way below the surface, disgorging the tissue removed—it cannot therefore be poisoned at this stage. My study of this interesting pest was interrupted, but I found in the one or two cases which I examined that the newly hatched caterpillar, before entering the orange (no particular place being chosen), spent some time in the calyx cavity, at the top of the fruit. Does it feed there, and could it be poisoned if spraying were carried out before the calyx cavity becomes closed? (cf. *Carpocapsa pomonella*).

A small, unidentified red mite causes a scabbing and silvering of oranges; the leaves of the tree appear to be unaffected.

Although *Icerya purchasi*, the Australian bug, occurs in the Protectorate, it does not seem to rank as a pest. It did not appear to thrive on trees which were artificially infected with it, at an altitude of 6000 ft. As showing how healthy crops and trees may suddenly suffer from migratory swarms of insects in Africa, the following case is of interest. A large swarm of small leaf-eating beetles (Halticinae?) suddenly appeared in a citrus orchard where they remained some ten days and did considerable damage to the young foliage. They appeared

immune to smoke and contact sprays and were difficult to catch in greasy bags on the ends of sticks. They finally disappeared completely after the trees had been sprayed with a stomach poison.

The rare butterfly, *Papilio mackinnoni*, was unexpectedly hatched out from caterpillars feeding on orange foliage.

Eriosoma lanigera on Apples. This pest thrives in the Protectorate, where there are one or two old apple orchards, which are not of blight-proof stock. The aphids penetrate to the cores of the apples. No winged forms have been seen.

Orgyia vetusta. The caterpillars of this moth are very harmful to the foliage of the quince, but the brood which was studied was almost exterminated by an Ichneumon parasite. The caterpillars always feed on the shady undersides of the leaves, and if violently shaken from the tree during the heat of the day they die upon the hot surface of the soil.

Duomitus capensis. The caterpillars of this Cossid moth bore into, riddle and kill the branches of the native tree *Cassia didimobotrya*.

Pests attacking Black Wattle (*Acacia decurrens*). A new pest of which I have never obtained the adult is the larva of what appears to be a Buprestid beetle. The eggs are laid in small scale-like cases on the surface of the trunk and branches; they are the only indication of the presence of the insect, and the cause of the tree's death is thus obscured. The flattened larvae bore in the cambium and, when numerous enough, kill the tree. I found both healthy and unhealthy trees to be attacked. The felling and bark-stripping of attacked trees and the removal of all weakly ones seem the best method of control. Trees might be girdled and, thus weakened, used as traps for the beetles to lay their eggs on.

Two allied pests in the form of a Jassid and a Capsid bug are very injurious to black wattle, large areas of which they attack. Nothing is known of their life-histories or natural food plants. It is not known whether they ever leave the wattle, on the sap of which they feed. Instead of the trees growing up straight and quickly, they come to a standstill and assume a miserable, entangled appearance, due to the production of numerous adventitious shoots. Often the tree grows away from this condition, but always is its growth delayed, a serious matter for the wattle-planter. In the chief wattle-growing area of B.E.A. the pests do not occur above an altitude of 6500 ft. and the chief estates escape. Slow initial growth caused by weeds, drought, weak seeds, bad planting and cultivation appears to aid these very serious pests.

WINTER COVER WASHES (*conclusion*).

By A. H. LEES, M.A.,

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At the end of the season 1913–14 the most satisfactory mixture found for covering and adhesive properties was one containing whiting, starch, glue and potassium dichromate. It had, however, two distinct disadvantages, first that hot water was required and second that its cost was too high. Accordingly in the season 1914–15 fresh attempts were made to find a mixture that did not labour under these disadvantages.

So far all substances that had been added to lime to increase the adherence of the mixture had had the opposite effect. Either they had caused brittleness or softness. What was clearly wanted was some body that would serve to tie the lime particles together without itself becoming crystalline or gritty when dry. In other words some suitable colloid substance seemed the most hopeful body to search for. Of these glue, starch, casein, resin and humus bodies immediately suggested themselves. It was clear from the beginning that only substances sufficiently cheap need be tried, as comparatively large quantities would have to be used in practice.

Glue had already been ruled out owing to its being rendered insoluble by lime but the others were given a trial. Starch mixes well with lime. The heat of the slaking lime can be used to gell the starch so that no hot water is required. It causes considerable thickening of the mixture and gives a hard and brittle coat. Table I (4).

Subjected to rain outside it becomes gelatinous and is soon washed off. It is therefore unsuitable. Resin was next tried. This could be incorporated in two ways. It could be added to the lime during slaking, in which case it did not increase the adhesiveness of the coat though neither did it detract therefrom, or it could be first boiled with

caustic soda and the solution added. This gave a much softer coat than the control. Resin therefore was not tried further. Table I (2).

Casein was added during slaking of the lime. It is soluble in alkalies so that a good mixture could be obtained. The resulting coat was, however, soft and useless. Table I (3).

Dried dung was used as a source of humus bodies and was added either immediately to the slaking lime or after a preliminary maceration with caustic soda. In both cases the mixture was unsatisfactory. Table I (5).

The use of dung suggested the possibility of increasing adhesiveness by incorporating some fibrous substance in the same manner that hair is used in plasters for house walls. At first filter-paper was used and afterwards newspaper. In both cases the paper was first treated with caustic soda and macerated and then the pulp was added to the slaked lime.

A considerable number of mixtures of different strengths both with and without the addition of starch were tried. On the whole the fibre decidedly improved the coat as it did away with the tendency to flakiness, though the addition of caustic soda seemed always to increase the softness. The method therefore of washing the pulp free from caustic soda was tried and the resulting coat was certainly harder. Some of these mixtures (Table I (6)–(12)) were tried outside (Table II), but the results were disappointing as all were washed off in a comparatively short time if subjected to heavy rain, and none of them could be considered satisfactory. This being the case it is not necessary to enter into details of their manufacture.

The last mixture of Tables I and II containing boiled linseed oil might have given good results if it had been possible, economically, to have used larger quantities. Its expense, however, ruled it out.

Effect of alkalies on glue solution.

The statement is made in the text-books that gelatine, the essential body in glue, is insoluble in alkalies and that gelatine or glue should not be used in spray fluids where free alkali is present.

This fact explains why mixtures of lime and glue were utter failures. Not only have they no sticking power but the mixture gives a very thin coat, very much thinner in fact than the same quantity of lime without glue would have given. No doubt caustic lime has an energetic action on glue. The mixture gives off bubbles of gas indicating that the glue not only becomes insoluble but is decomposed at the same

time. The thinning effect is very characteristic and may be explained hypothetically as follows:

When lime is slaked under water it breaks up into a great number of extremely fine particles. Whether it is the fineness of the particles or whether it is associated with some other property the solid matter appears to be in a semi-gelatinous state. It is bulky and only sinks very slowly. If allowed to dry and then re-wetted the semi-gelatinous state is not re-acquired, but the particles remain gritty as though they had become flocculated. If a solution of glue is added to milk of lime freshly slaked the probability is that the glue precipitate so formed unites the minute lime particles into larger ones, so that the mixture at once loses covering power and shows the characteristic "thinning." It seemed therefore profitable in view of the uncertainty of the action of alkalies on glue to investigate the reaction. When 10 % solutions of caustic soda were added to hot glue solutions an immediate fibrous precipitate was obtained. A similar result was obtained by the addition of a hot 1 % solution and an immediate slight turbidity with so weak an alkali as lime water provided hot solutions were used.

On the other hand if cold 10 % caustic soda solution was added to cold glue solution no precipitate appeared for several hours. The same, as was to be expected, happened if 1 % caustic soda or lime water were added in the cold. The fact that the reaction between alkali and glue could be slowed down opened up new possibilities for lime mixtures.

Further experimentation with milk of lime showed that thinning occurred if incompletely slaked cold milk of lime or completely slaked hot milk of lime were added to glue, while it did not occur if cold well-slaked lime were used.

In working with milk of lime it is of course impossible to see whether the gelatine of the glue is actually precipitated, but it is safe to assume that loss of covering power in the mixture indicates precipitation. From these facts it appeared probable that a satisfactory mixture could be made by adding glue solution to cold well-slaked lime. Such mixtures were made up in the laboratory and it was found that one having the quantities lime 20, glue 2, water 100 gave a firm but thin coat. No sudden loss of covering power was here noticed such as follows when hot or unslaked lime acts on glue, but the coat was rather thinner though much firmer than the control lime 20, water 100.

This slight loss of covering power is no doubt due to the glue in solution. Gelatine is used in some summer sprays in order to increase

their wetting and spreading power and probably the same spreading effect took place in this mixture. By increasing the lime from 20 to 30 a thick and firm coat was obtained. This 30, 2, 100 mixture was tried out of doors where it resisted rain fairly well but still did weather somewhat. It appeared therefore that the glue was not made insoluble on the tree quickly enough. Two methods suggested themselves as likely to overcome the difficulty. The first was to use the lime warm and so to get the glue gradually to become insoluble as it dried on the tree.

This was actually done in one or two cases with successful results but it was found difficult to judge the correct temperature and success was always a matter of luck. Any delay in getting the spray on the tree, owing for instance to choked nozzles, resulted in the glue being made insoluble before it reached the tree and a loss of covering and adhesive power.

The second method was to use potassium dichromate as had already been done the season before when working with glue mixtures. This causes the glue to become insoluble when exposed to light, thus holding the lime coat together. This method proved quite successful. It is necessary, however, to use the correct amount of dichromate. If too much is used immediate thinning is produced and the mixture is spoiled. If only a little too much is used the lime coat on the tree becomes too flaky though at the same time remarkably hard. So hard is it that if one rubs one's hand on the trunk of a tree so sprayed no lime comes off at all and the surface gives one the impression of fine emery paper. The best quantity to use is expressed in the formula:

Lime	30 lbs
Glue	2 lbs
Potassium dichromate ...	$\frac{3}{8}$ oz.
Water	10 gallons

To make this mixture 30 pounds of lime are placed in a tub and 6 gallons of water poured over it and allowed to slake. When the lime begins to boil add 2 more gallons of water gradually so as to keep the slaking mixture always as hot as possible. Then 2 pounds of glue are put into a pail with one gallon of cold water and occasionally stirred. After the lime has slaked and become quite cold, which takes 6–12 hours, a gallon of hot water is added to the glue which then immediately goes into solution. This is then added to the lime, well

stirred and filtered through a sieve with 16 meshes to the inch into the spraying machine.

Lastly the potassium dichromate previously dissolved in a small quantity of water is poured into the machine and stirred up. The mixture is then ready for application.

Where the lime is very good the amount might be reduced to 25 lbs as 30 lbs of good lime sometimes makes the mixture too thick for easy straining. It is important to soak glue first in cold water as a direct application of hot leads to the formation of intractable lumps. Where it is desired to avoid the use of hot water, as in continuous spraying, the following procedure may be adopted.

One lot of lime is slaked with water and allowed to cool as above described. Then a second lot is made up and by means of the heat evolved the glue for the first lot can be dissolved by standing the pail of soaked glue in the hot lime. It only needs a temperature of about 100° F. to dissolve glue that has been previously soaked and this is easily obtained by this method.

This lime-glue-dichromate mixture has been tried against ordinary lime-wash at Long Ashton and has given decidedly superior results. An application to an apple tree stopped aphis hatching to such an extent that hardly an aphis was to be seen on it throughout the season though control trees were very badly attacked. The tree stood out all the season from its fellows by the healthy green uncurled leaves and at the end of the season by its very numerous well-developed fruit buds.

Hide glue can be obtained in hundredweight quantities at $4\frac{1}{2}d.$ a pound so that the cost of the spray per 10 gallons works out as follows:

	s.	d.
Lime 30 lbs @ 1*s.* per cwt.		3
Glue 2 lbs @ $4\frac{1}{2}d.$		9
Potassium dichromate $\frac{3}{8}$ oz. @ 6*d.* per lb. ...		$\frac{1}{7}$
Total	1	$0\frac{1}{7}$

giving an approximate cost of $1\frac{1}{4}d.$ per gallon.

TABLE I. *Indoor Trials.*

	Parts by weight including in each case water 100		Remarks	Resulting coat
(1)	Lime	20	Control wash	
(2)	Lime	20	Resin added during slaking	About same as control
	Resin	$\frac{1}{8}$	Resin dissolved in caustic soda	Soft and brittle
(3)	Lime	20	Casein added during slaking	Softer than control
	Casein	$\frac{1}{8}$		
(4)	Lime	20	... ...	Hard but very brittle
	Starch	$\frac{1}{8}$		
(5)	Lime	20	Dung macerated first with a little caustic soda	Soft and thin
	Dung	2		
(6)	Lime	20	... ...	Well matted coat firm but uneven
	Filter-paper .	*xs*		
	Caustic soda.	*xs*		
(7)	Lime	20	... ...	Not quite so firm as (6) but thick and good
	Filter-paper .	$\frac{1}{2}$		
	Caustic soda.	$\frac{1}{4}$		
	Starch	$\frac{1}{2}$		
(8)	Lime	20	... ...	About the same as (7)
	Newspaper ...	$\frac{1}{2}$		
	Caustic soda.	$\frac{1}{8}$		
	Starch	$\frac{1}{2}$		
(9)	Lime	20	... ...	Moderately hard, not flaky Firm
	Washed pulp	1		
(10)	Lime	20	... ...	Softer than (9)
	Unwashed pulp	1		
(11)	Lime	20	... ...	Irregular in thickness, firm but fairly hard
	Washed pulp	1		
	Starch	1		
(12)	Lime	20	... ...	Not quite so firm as (11)
	Unwashed pulp	1		
	Starch	1		
(13)	Lime	20	Starch treated with the caustic soda and the boiled oil stirred in and whole mixture added to the lime	Not enough boiled oil to affect the coat
	Boiled oil	4		
	Starch	2		
	Caustic soda.	·4		

TABLE II. *Outdoor Trials.*

Figures indicate parts by weight and include in each case water 100

	Lime	Newspaper	Caustic soda	Starch	Washed Newspaper pulp	Boiled oil	Remarks	Results
(1)	20	—	—	—	$\frac{1}{2}$	—	—	Fair coat
(2)	20	—	—	$\frac{1}{2}$	$\frac{1}{2}$	—	—	Rather better than (1)
(3)	20	—	—	1	$\frac{1}{2}$	—	—	Resisted rain fairly well
(4)	20	—	—	$1\frac{1}{2}$	1	—	Kept 12 hrs before application	Rather spotty but only slightly flaky
(5)	20	—	—	—	$\frac{1}{2}$	—	Applied fresh	Very flaky
(6)	20	—	—	—	$\frac{1}{2}$	—	Kept 6 hrs before application	Not nearly so flaky as (5)
(7)	10	$\frac{1}{2}$	$\frac{1}{8}$	3	—	—	—	Slightly flaky
(8)	10	—	—	3	$\frac{1}{2}$	—	—	Powdery
(9)	10	—	·4	2	—	2	—	Too thin

SOME OBSERVATIONS ON THE EGG OF *PSYLLA MALI.*

By A. H. LEES, M.A.,

Plant Pathologist, University of Bristol, Agricultural and Horticultural Research Station.

For some years it has been known that the egg of the Apple Sucker, *Psylla mali*, hatches at slightly different times on different varieties of apple trees. Theobald in his *Insect Pests of Fruit* makes the following remarks:

"Another point of great interest concerning the eggs is the irregularity with which they hatch out. The date not only varies in different localities and in different years but during the same season in the same plantation. They incubate at different periods according to the variety of apple upon which they are situated. This may be due to the heat generated by the flow of sap regulating their hatching to the time of the bursting of the buds."

So close was the correspondence between the date of bud bursting and egg hatching that it appeared as if there might be some intimate relation between the egg and the host plant. Investigations were therefore begun by the author in 1911 but owing to lack of opportunity could not be continued till 1915. A description of the egg may be found in Theobald's *Insect Pests of Fruit* where a certain process of the egg is mentioned and figured. He describes the egg thus:

"The ova when first laid are almost white, then they become creamy yellow and later assume a faintly rusty-red hue before hatching. Furley describes them as becoming a pale yellow-red also. They are elongated oval in form, somewhat pointed at the ends, one of which is produced into a thin process which is apparently curled under the egg and cannot easily be seen unless the ovum is very carefully removed. What this process is for we do not at present know."

Under ordinary circumstances this is the only process that can

be seen when eggs are taken off a twig for observation. For further investigation it was found necessary to make use of special methods of preparation.

Methods of Preparation.

Treatment with 10 *per cent. caustic soda.* If the egg-covered twig be immersed for several days in cold 10 per cent. caustic soda it is possible to withdraw the egg from the plant tissues in which it is imbedded without injury to it. The soda softens the plant tissues and in the space of a few days does not destroy the structure of the larva. In some cases by careful manipulation with mounted needles it was possible to withdraw the larva with its accompanying membranes from the egg shell but usually the larva came away with only one membrane.

Treatment with bleaching powder solution. In order to study the relation of the egg membranes with more certainty it was found necessary to use some substance that would attach chitin. The most convenient was a mixture of concentrated bleaching powder solution and 10 per cent. caustic soda in about equal parts. This mixture when filtered from the precipitated hydroxide of calcium gives what is practically Eau de Labarraque with excess of soda. By judicious use it is possible to attack the outer chitinous membrane so as nearly to dissolve it without materially injuring the internal structures.

Mounting. In most cases concentrated carbolic acid with a small proportion of added glycerine was used. This mixture clears well and gives preparations sufficiently permanent for observation.

Material.

As it was desired to study the relation of parts of the larva and egg it was necessary to collect material just before hatching commenced. It was accordingly collected in the middle of April and preserved in alcohol.

One difficulty in this investigation was the very small number of perfectly formed advanced embryos that could be found. Other writers have pointed out the frequent presence of numerous empty egg shells, but in addition to this I found large numbers of eggs that appeared fairly normal to the naked eye but which proved on further examination to be much retarded in development. It is probable that these eggs were arrested in growth since the normal egg was just

about to hatch, but at the same time it is of course possible that further development might have taken place though this seems unlikely in view of their very backward condition.

The eggs are laid in greatest number at the base of the fruit spurs, often sheltering under the edge of a scale scar; frequently one side of the spur has more eggs laid on it than the other. I have never observed that the eggs are orientated in a line parallel to the axis of the twig as mentioned by Awati (*Ann. App. Biol.* Vol. 1, Nos. 3 and 4, p. 248).

As a rule there are but few eggs laid on the vegetative shoots of one year's growth. This occurs only in cases where there is considerable crowding of eggs on the fruit spurs.

Description of the Egg.

By using the caustic soda treatment combined with the use of bleaching powder solution it is possible to distinguish three membranes round the developing larva, which for convenience of description may be called the outer, middle, and inner membranes.

The outer membrane. This is comparatively thick and has a sculptured surface (Fig. 2). It has two processes. One is situated at the pointed end and is solid, being continuous with the thick chitin of the outer membrane. It is hyaline and lacks the irregularity of the sculptured surface which is present on the rest of the outer membrane. It is scarcely possible that it has any influence on the hatching of the egg and appears as if it were pulled out at the time of secretion when the chitin was still soft, in much the same way as a glass rod heated in a flame and pulled forcibly apart leaves a tail of glass (Fig. 2).

The other process is hollow and is inserted through the back into the cortex of the twig where it ends blindly (Figs. 1 and 3).

There is a certain amount of disturbance in the cortex as the cells immediately round the process are darker in colour as if cork had been formed as the result of irritation.

This process certainly serves to anchor the egg and it is possible that by its penetration into the tissues some kind of physiological reaction is caused between the egg and the tree. Of what nature this reaction is it would be impossible to say with any certainty.

It is at any rate certain that eggs situated on early leafing trees hatch correspondingly earlier than those on late leafing trees. Earlier hatching is therefore associated with earlier rise of sap in the tree. It would therefore appear not impossible that the sudden increase of

sap in the vicinity of the process would cause an equally sudden increase of pressure inside the egg which might be just enough to cause hatching if the larva were in an advanced enough state.

The middle membrane. This is thin and is apparently not chitinous as picric acid does not stain it. It has no sculpturings like the outer membrane. It possesses a hollow thin-walled process which follows the position of the outer membrane process, reaching in the normal

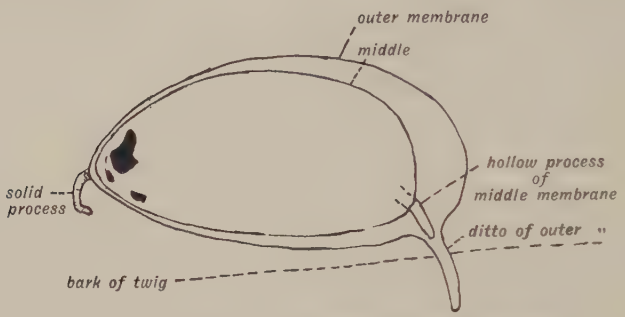

Fig. 1. Outline of egg membranes and processes.

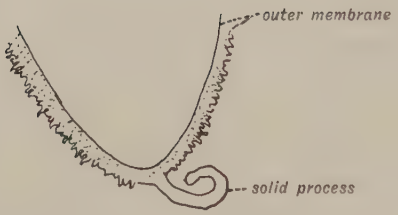

Fig. 2. Outer membrane.

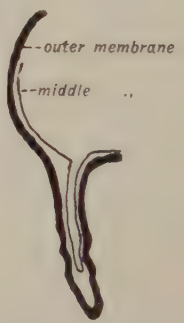

Fig. 3. Hollow process (highly magnified).

position about two-thirds way down it (Fig. 3). On treatment with reagents some contraction usually takes place so that it may be partially withdrawn (Fig. 1).

The inner membrane. This is extremely thin and is easily destroyed when preparing specimens, so that unless some care is exercised it cannot be seen. It has no process, but at the anterior end are two tubercles and a peculiar modified area (Figs. 1, 4, 5). The larger (Fig. 6 A) is dorsally situated and doubtless is the chief agent used

for breaking the outer membrane. The smaller is ventrally situated and does not appear to be in such a position as to be of service in bursting the outer shell.

At the most anterior end of the inner membrane is a peculiarly

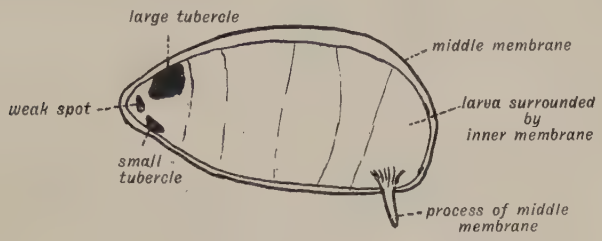

Fig. 4. Egg divested of outer membrane.

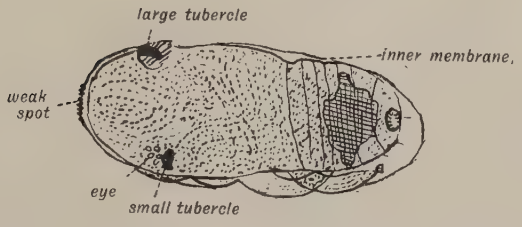

Fig. 5. Egg divested of outer and middle membranes.

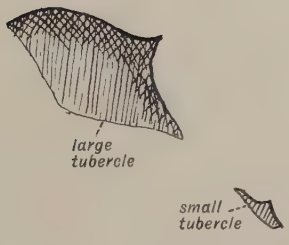

Fig. 6 A. The tubercles.

Fig. 6 B. Weak spot in inner membranes.

modified area. Viewed under a high power it appears as a series of radiating thickened lines (Fig. 6 B). It has the appearance of being specially formed for ensuring the bursting of the membrane at the time of egg hatching.

That these tubercles are not on the larva, as suggested by Awati,

but on the inner membrane is shown by the fact that a newly hatched larva or one in which hatching has been induced artificially is perfectly free from them (Fig. 7).

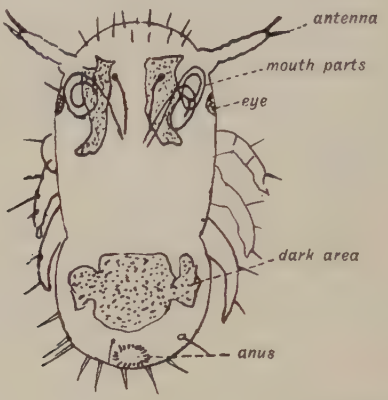

Fig. 7. Larva removed from egg membranes.

Position of larva in egg membranes. In Fig. 8, the original of which was prepared by carefully treating an egg with the bleaching powder mixture, the larva is shown *in situ*. The outer membrane is nearly dissolved away and the process of the middle membrane can be seen partially withdrawn from its normal position. The larva lies with its anterior end at the pointed end of the egg with its ventral surface towards the twig. Its posterior end is towards the hollow process and its closely packed legs are situated immediately over it.

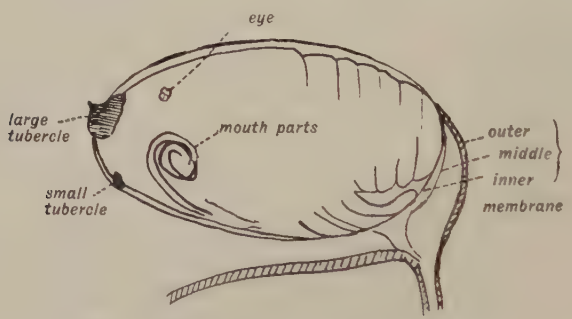

Fig. 8. Relation of larva to membranes.

At first it was thought that possibly the mouth parts went down the hollow process and served as a physiological connection between the apple tree and the egg. When examining specimens of the entire egg some straight lines could be seen in the hollow process of the outer

membrane, but subsequent more careful examination showed these to be the two edges of the hollow process of the middle membrane.

The larva is entirely shut off from the hollow processes by the inner membrane and the mouth parts in every specimen examined were found curled up anteriorly and ventrally. On hatching the outer and middle membranes are left with their processes imbedded in the twig.

Morphology and function of egg membranes. In most insect eggs two membranes can be observed, the inner, or oolemma, and the outer, or chorion. The latter is often divided into exo- and endochorion connected by chitinous trabeculae, the ends of which in surface view give rise to the sculpturings of the outer egg shell. It is clear that in the case of *Psylla mali* the inner membrane is the oolemma and the outer is the chorion. It is difficult to see what the middle membrane corresponds to.

The relation of the egg coverings is peculiar and suggestive. If the object were simply to secure an anchoring mechanism the outer process would seem sufficient. It is possible, however, that there may be some physiological connection between the egg and the apple twig. The facts already quoted of the close relation between the time of hatching and the time of bud bursting in different varieties of apples would seem to suggest this. Until more direct evidence is obtained, however, it would be premature to press this hypothesis.

SCIARA TRITICI, COQ. A FLY INJURIOUS TO SEEDLINGS.

By F. W. EDWARDS, B.A., F.E.S.,
and C. B. WILLIAMS, M.A., F.E.S.

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Until comparatively recent years few or no instances were known of damage to plants by fly larvae of the genus *Sciara*, and even in some recorded cases it was supposed that the injury caused by the *Sciara* larvae was only of a secondary nature, and that they only attacked parts of plants where decay had already begun to set in owing to the attacks of some other pest. Recent investigations by several observers in the United States have, however, shown that in a number of instances the damage must be directly attributed to the larvae of some species of *Sciara*.

No definite records have been published on this subject in Britain, and it has therefore been thought worth while to issue the following notes on a species of *Sciara* which certainly causes damage to potted plants in this country. Added interest is given by the fact that the species in question has not previously been recorded in Great Britain, or even in Europe, though it is quite uncertain where it had its original home.

In the autumn of 1911 specimens of a *Sciara* were sent me for identification by Mr C. B. Williams, from Merton, Surrey, where they were damaging *Primula* seedlings. At that time I was unable to identify these specimens with any described European species, and they were in consequence put on one side. The question was reopened in June of the present year (1915) when living specimens of the same species were received from Mr W. H. St Quintin, of Rillington, Yorks, whose young orchid plants had suffered from their attacks. I then studied the literature more carefully and found that the specimens were without

any doubt identical with the *Sciara tritici* described by Coquillet from North America in 1895.

Coquillet made positive statements as to the injury caused by the larvae to young wheat plants. He says (*Insect Life*, Vol. VII, 1895, p. 407): "On March 17, 1885 a large number of adults issued from a jar containing plants of this kind that had attained a height of from 6 to 8 inches. They already indicated an unhealthy growth by a more or less yellowish appearance, and an examination of their roots revealed the fact that these had been severely injured by the larvae, many of which were still present, and were observed to feed upon the roots and interior of the stems both below the surface of the soil as well as in the interior of the stems a short distance above the surface. As many as eight larvae were sometimes found in one of the stems, and they had also penetrated the kernels of wheat from which the plants sprang; many of the smaller rootlets had also been devoured, or more or less injured, by them."

Mr St Quintin was equally definite in attributing the damage to the *Sciara* larvae[1], as the following extract from his letter will show:

"It is causing great trouble and loss to raisers of exotic orchids and seems to be on the increase. The books written only a few years back do not allude to it amongst the insect pests which trouble orchids under cultivation. Certainly here, though we have been raising orchids (from seed) for about 8 years, until the last three or four we have never noticed it. It is particularly troublesome this spring, but it seems to fly all the year round, at any rate whenever we have young orchid plants at a particular stage, we find it in our seedling house. This house is kept very moist, and with a temperature of from 70°–80° F. according as the day is dull or sunny.

"When the little plants have acquired the real root, the fly does not trouble them, but at the very early stage when the plant draws its nourishment from root-hairs it cuts these off and starves the plant. When it has destroyed all the little plants in a pot it turns to the *Sphagnum* moss and devours that.

"Fumigation kills the insect when it is on the wing, but it appears to emerge at all hours of the day, and does not mind the fumigation in the larval and pupal stages.

"It seems a question whether the fly came with the *Osmunda* fibre,

[1] Some of these larvae have been handed to Mons. D. Keilin, who will describe them in his forthcoming work on the early stages of the Diptera.

which has within the last few years been more or less used in the compost for raising orchids from seed, or in the *Sphagnum* moss, which has always been used since the first experiments in raising epiphytic orchids. The *Osmunda* fern fibre comes from N. America, the *Sphagnum* used is British."

In the case of these orchids the possibility should not be overlooked that at least some of the damage may be caused by springtails (*Collembola*). These insects were present in large numbers in the contents of some pots sent to the British Museum by Mr St Quintin, and it is worth recalling that in 1902 Prof. F. V. Theobald recorded a case of injury to seedling orchids by springtails in Surrey (vide *First Report on Economic Zoology,* Brit. Mus. Nat. Hist., p. 110). In this last-mentioned case specimens of a Sciarid fly (*Zygoneura* sp.) were found in addition to the *Collembola*, but Theobald had little doubt that the damage was really caused by the latter. In Mr St Quintin's pots both the *Collembola* and the *Sciara* larvae were much more numerous in the *Osmunda* compost than in the *Sphagnum*.

Prof. Theobald has recently had a species of *Sciara* injuring tomato seedlings at Wye, and at my request he kindly sent me specimens of the fly concerned; contrary to expectation they proved not to be *S. tritici*, although they were not in sufficiently good preservation to be determined accurately.

Sciara tritici is a small fly about 2 mm. long, differing from most of its congeners in the reddish coloration of the thorax, somewhat darker towards the margins when viewed from above; the abdomen is rather darker than the thorax. Its most obvious distinguishing feature however—by which it may be separated from all the other members of the genus so far described—is the possession of a whitish-yellow stripe on the dark brown pleurae, connecting the bases of the front and middle coxae. There is also a whitish spot below the shoulder. It belongs to the group II.A.1.C.*b* of Winnertz's monograph. Coquillet, in the paper cited, gives a good description and figures the larva, pupa and adult; from these the species will be easily recognised, but it may be pointed out that the figure of the wing is not accurate, the subcostal cell being made much too narrow.

F. W. E.

The British Museum of Natural History,
November, 1915.

Seedlings, particularly *Primula* and *Campanula*, under glass at this Institution, have, at various times during the past few years, suffered slightly from the attacks of small Dipterous larvae. The larva was of the Mycetophilid type, very long and slender with a shining black head, and adults bred out and captured in the hot-houses have been identified by Mr Edwards as *Sciara tritici* as mentioned above.

The larvae are found usually below the surface of the soil where they eat the roots and the collar of the seedlings. Frequently the root was eaten right across below the collar so that the dying rosette of the seedling would be found resting on the soil unattached to the roots. Sometimes a cotyledon or a small leaf which was touching the surface of the soil would be damaged on its lower surface. Pupae were found also just below the surface and the empty skins projecting slightly above having either worked their way there before emergence or been dragged to this position by the emerging fly. The adults were found commonly running about on the surface of the soil, on the sides of the boxes and pots containing the seedlings and occasionally resting underneath the boxes. They ran actively, were reluctant in taking to flight and their flight was not powerful.

Three larvae, quite large on the 9th January, 1912, were given a small piece of root of a larger *Campanula* which they fed on readily, removing the softer tissues and leaving the fibrous vascular bundles. They spun a slight web and pupated on the same web on the 19th, 20th, and 21st of January. The pupa was pale shining yellow and 2 mm. long by 0·7 mm. broad. A day or two after pupation the eyes began to darken. After four days the anterior end of the pupa darkened and this gradually spread till the whole, just before emergence, was dark brown. One adult emerged on the 25th and two on the 27th, giving a pupal stage of 6–7 days.

In emergence the pupal skin split along each side of the antennae, leaving the covering of these free except at the base where it was joined to the ventral surface of the pupa case.

Another dipteron, *Scatella quadrata*, is nearly always associated with *Sciara tritici* but as yet no damage has been traced to it.

A *Sciara* larva, indistinguishable from the above, was found *out of doors* in the root of an old *Campanula*. It pupated among the fibres of the root but unfortunately died in the pupal stage.

The pest has been kept under control by regular fumigation of the houses, chiefly with fumigants containing nicotine. It was also

largely destroyed by the sterilization of the soil by heating which was tried experimentally for some time. This method, however, was abandoned as it was not found satisfactory for other reasons.

It is suggested by Mr St Quintin (see above) that the species in his case was introduced from the United States in *Osmunda* fibre. In our houses there were a few orchids growing in *Osmunda* fibre and it is possible that they might have come in this from some other locality in England. It is probable that it will be found widely distributed in greenhouses in this country.

C. B. W.

The John Innes Horticultural Institution,
Merton, Surrey.
November, 1915.

ON A CASE OF RECOVERY FROM MOSAIC DISEASE OF TOMATO.

By W. B. BRIERLEY.

(*Laboratory of Plant Pathology, Royal Botanic Gardens, Kew.*)

During recent years the attention of plant pathologists has been increasingly directed to the study of certain diseases of obscure etiology, which have for convenience been classed apart under the term "physiological." Of these one of the most interesting yet least understood is Mosaic disease, often known as "Frenching," "Calico" or "Mottle Top," and found in a variety of plants chiefly members of the Solanaceae. Great attention has been devoted to mosaic disease of tobacco, but little focused on the study of this malady in tomato. In 1908, however, Clinton[1] published the important fact that the mosaic disease of tobacco is communicable to healthy tomato plants and *vice versa*; and this conclusion, although opposed by Westerdijk[2] in an important paper appearing two years later, is generally accepted.

Excellent recent accounts of the past history and present position of the question of mosaic disease will be found in the papers of Melchers[3], Allard[4] and Clinton[5], and further discussion here is unnecessary.

The interest of the present note lies in the exceedingly rare occurrence of recovery from the disease.

In 1898 Beijerinck[6] stated, but without entering into any details, that in some instances plants apparently showed a temporary recovery.

Woods[7], four years later, writes: "The mosaic nature of the trouble and the fact that under some conditions the plants may grow out of the disease."

[1] *Rept. Conn. Agr. Expt. Sta.* (1908).
[2] *Mededeel. Phytopath. Lab.* "*Willie Commelin Scholten,*" Amsterdam, I. (1910).
[3] *Ohio Nat.* XIII. No. 8 (1913).
[4] *Bull. Torr. Bot. Club*, 41 (1914).
[5] *Rept. Conn. Agr. Expt. Sta.* (1914).
[6] *Verhandel. Kon. Akad. Wetensch.* Amsterdam, XI. 6/5 (1898).
[7] *U.S. Dept. Agr. Bur. Pl. Ind. Bull.* 18 (1902).

In 1910 Lodewijks[1] published the results of his investigations on mosaic disease. He covered the upper diseased portions of mosaic plants and at the same time exposed the lower apparently healthy leaves to light of different colours. Under these conditions he found that diffused light checked the disease, red light decreased it, and blue light completely cured plants of the malady. These very striking results still await confirmation.

Allard writing in 1914[2] states that "Some practical growers have claimed that the disease can be checked if taken at its first appearance by pulling affected plants until they are loosened from the soil." Of this he remarks "There is little in this view however to recommend its general adoption" and that "In the writer's experimental tests many thousands of affected plants have been kept under observation through all phases of the disease. In no instance has there been a case of actual recovery from true mosaic disease."

Allard's experience confirms that of practically all recent investigators of this malady.

Thus Clinton[3] writes: "A plant which once becomes infected remains so, and all subsequent new growth (at least that above the lowest infected leaf) usually, if not always, becomes calicoed." "The clause is placed in parentheses because we are not sure whether the calico virus is carried downward in the stem as far as, or as readily as it is carried upward. If not, it stands to reason that if plants were calicoed late in life by touching and infecting the upper leaves only, and some time later were cut off at the base with a sterile knife the resulting suckers would not so surely calico as those from plants whose basal leaves were calicoed. Some evidence along this line is shown by experiment No. 124, where the juice from an apparently healthy leaf at the base of a plant calicoed above, failed to infect another plant when applied to it."

Chapman[4], writing in 1913, states: "Once the disease appears on a plant, all subsequent growth will be mosaic to a greater or less extent."

Moreover any apparent cases of recovery in the past are rendered extremely improbable in view of the fact recently demonstrated by Allard[5] that the virus of the disease may be present in a highly infective condition, and yet produce no external symptoms. This fact, that an individual may be diseased and serve as a centre of infection, whilst

[1] *Rec. Trav. Neerland.* VII. (1910).
[2] *U.S. Dept. Agr. Bull.* 40 (1914).
[3] *loc. cit.* (1914).
[4] *Ann. Rept. Mass. Agr. Expt. Sta.* Pt. XI. No. 31 (1913).
[5] *loc. cit.*

itself not showing any signs of disease, is well known to animal pathologists but does not seem to have been previously applied to plants.

In the course of some preliminary investigations on the mosaic disease of tomato which are being carried out in the pathological laboratory at Kew, the freedom from disease of new shoots springing from a diseased stock was noted. The plant in question was one of two which were received on September 9th, from a grower in whose houses tomatoes have shown the disease for some years. The roots were shaken partly free from soil, and were found to be well-developed. The plants had been topped some time previously and were each bearing small clusters of immature fruit. The foliage was good but calicoed down to the lowest leaf. The plants were posted to the laboratory and on receipt some two days later were immediately potted in light loamy soil and placed on the floor in a cool glasshouse.

One plant shortly died and was destroyed. Of the other all the leaves and the upper portion of the shoot withered and were cut away. Three new shoots however developed, all originating on the stem well above the lower leaves and these appeared perfectly normal, *i.e.* were healthy shoots from a diseased stock.

Now two criticisms may be made which are vital to this observation. One concerns the condition of the original plant, for if the diagnosis of the malady as mosaic disease be a mistaken one, the observation has no interest. The second concerns the new shoots, for if the disease is not really absent from them but present in a latent form, the apparent recovery merely serves to confirm Allard's observation.

But it is the lack of a final criterion which is the fundamental difficulty in all investigations of mosaic disease, for where there is apparently no causal organism, the rules of Koch are inapplicable.

Concerning the first criticism—that the original plant possibly did not suffer from mosaic disease—two criteria only are available; one, the symptoms of the disease; and the other its infectious quality.

Now there is no tomato disease of known parasitic origin, which produces external symptoms conceivably to be mistaken for those of calico or mosaic disease. On the other hand chlorotic or etiolated plants, or those suffering from excess or deficiency of food and other materials in the soil, or from soil sickness, whilst often assuming a greyish or yellowish colour, never show the characteristic and peculiar blotching or mottling of calico.

The infectious nature of the malady from which the original plant suffered is a question only to be determined by experiment. The

withered leaves which had been thrown away earlier were carefully collected, and those which had been attacked by various saprophytic fungi rejected. The few remaining portions were thoroughly and rapidly washed in sterile water, and then the moist fragments ground to a pulp in a watch glass and extracted with 0·25 c.c. of sterile water. This was filtered twice through two thicknesses of finest filter-paper to eliminate as many bacteria as possible and any fungal spores. The filtrate was then inoculated into the leaves, buds and stems of twelve seedling tomato plants, and as a control twelve other seedlings were similarly treated with sterile water and the pots placed on the same shelf in a glass house. Of the sixteen plants which survived Black Neck (*Phytophthora* sp. (*omnivora*?)), frost and the undue proximity of hot pipes, five out of nine inoculated with "virus" showed mosaic disease, whilst this was completely absent from the seven remaining controls. Considering the old withered condition of the original leaves, the treatment they received and the dilution of the "virus" derived from them, the fact that five out of nine plants should be calicoed, removes any doubt that the original plant suffered from this disease. As a further precaution new healthy seedlings were inoculated from the experimental plants and the mosaic condition obtained a second time, with again a total absence in the control plants.

The second criticism—that the "virus" is not absent, but merely latent in the new apparently healthy shoots—is again a question for experimental evidence only. The expressed sap of one of the shoots was inoculated into seedling plants, and controls were similarly inoculated with normal plant juice. No trace of mosaic disease was obtained in either series of plants; and a second set of seedlings inoculated from the first gave a similar negative result. There can therefore be no doubt that the new shoots arising from the calicoed stock were absolutely free from mosaic disease.

A further point of extraordinary interest arises out of the above experiments,—are the new shoots growing from the calicoed stock immune to the "virus" of the disease; *i.e.*, have they acquired immunity as the result of one attack?

To test this the two remaining shoots were inoculated with "virus," but unfortunately the plant was killed outright by frost ten days later, at this time showing no sign of disease. As the incubation period of the malady is variable, and rarely less than one week, this, perhaps the most interesting experiment, was a failure.

"WILT" OR "CROWN-ROT" DISEASE OF CARNATIONS CAUSED BY *FUSARIUM* SP.

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(With Plates XXXVII—XL.)

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Introduction.

Sturgis[1] in 1897 described a disease in carnations known commonly as "Die-back" or "Stem-rot," as due to a *Fusarium* sp. He first observed the disease on the *William Scott* variety growing in the Station

[1] Sturgis, Wm. C., "Preliminary Investigation on a Disease of Carnations," *Ann. Rep. Conn. Agric. Exp. Station*, Part III, 1897, pp. 175–181.

greenhouse, and subsequent enquiry showed this trouble to be the cause of great loss of certain varieties.

The disease he describes as showing first a yellowing of the lower leaves which later become dry and dead. As it progresses the whole plant becomes involved until finally death ensues. There was no sudden wilting of the plants; thus those affected resembled plants from which the water or food supply was gradually withdrawn.

In rare instances where only a portion of a plant appeared affected, he succeeded in checking the progress of the trouble by removal of the infected portion, but as a rule the appearance of the first symptoms indicated death to the plant sooner or later.

The stalk just below the soil showed discoloration and disintegration in the outer layers, and the cambium cells were partially destroyed, while permeating the wood and collecting in masses in the larger vessels and ducts was a fungous mycelium consisting of delicate colourless threads.

He finally obtained spores of the fungus on an old plant which had died from the trouble and thus determined the causal fungus as being a *Fusarium* sp.

Pure cultures were easily obtained by inoculating culture tubes with bits of the fungus-infected material.

Sturgis succeeded in inducing the disease in plants planted in pots, the contents of which after sterilisation were infected with the fungus. Other pots, the contents of which too were sterilised but into which the fungus was not introduced, served as controls. In a second series, the contents of the pots were not sterilised but otherwise treated as above. The disease also appeared in some of the control plants of the first series, and he attributed its outbreak to the presence of the fungus in the tissues of the original cuttings. In both cases where a decided outbreak occurred in the sterilised soil, the cuttings were obtained from a locality infested with the fungus and were rooted in compost from the same locality.

At the time of publication only one form of spore had been observed, a spindle-shaped or fusiform spore, pointed at both ends, hyaline, slightly curved, 3–5 septate and measuring 25–38μ × 3·5–4μ. These spores were borne singly or in small clusters on the tips of the sides of short branches of the mycelium, and seen in mass presented a pale salmon pink colour.

Under unfavourable conditions these spores were observed to pass over into bodies resembling resting spores, which on germination produced a mycelium bearing the typical *Fusarium* spores.

Stewart[1] writing in 1898 states that under the popular names "Stem-rot" and "Die-back" have been confused two distinct diseases in carnations.

The one due to *Rhizoctonia* causes plants to wilt suddenly by rotting of the stem at or just below the surface of the soil. The cortex of diseased plants separates readily from the wood, the pith is attacked quite easily, becoming water-soaked in appearance and filled with fungous hyphae.

The other, caused by a *Fusarium* sp., attacks chiefly the stem and larger branches, discolouring the wood and killing the cortex but rarely causing a soft rot. The affected plants die gradually with yellowing or drying of the foliage. The fungus rarely fruits on the outside of the stem but does so frequently in the cambium and pith of stems long dead. Stewart[2] has also described a leaf-spot disease in carnations caused by a *Fusarium* sp. Of this disease he says: "A bunch of carnations of the variety *Emily Pierson* was quite seriously affected with a peculiar leaf spot, the spots varied in length from $\frac{1}{8}$–1 in. The smaller ones were elliptical but the larger ones occupied the entire width of the leaf and were irregular at the ends. They were covered with a pinkish-grey mold and irregularly dotted at the centre with the light yellow spore masses of a species of *Fusarium*. Many of the worst affected leaves were dying." The author found the *Fusarium* always originating in a rust pustule and, though not capable of infecting uninjured leaves, readily entering through the epidermis which had been broken by the rust fungus, and bringing about decay of the leaf tissue. He further remarks that inoculation experiments may show this fungus to be identical with the *Fusarium* causing stem-rot in carnations.

In conclusion, he states that the carnations were grown under conditions exceptionally favourable to the attack of fungi, but they did well and were free from disease with the exception of the *Fusarium* leaf spot and a moderate attack of rust.

The disease herein described has much in common with the "die-back" or "stem-rot" disease of Sturgis[3]. It, too, is caused by a *Fusarium* sp., but whether it is the same species in the two instances

[1] Stewart, F. C., "Stem Rot Diseases of Carnations," *Exp. Station Records*, 1898–99, Vol. x.

[2] Stewart, F. C., "A *Fusarium* leaf-spot of Carnations." *N.Y.* (*Geneva*) *Agric. Exp. Station Bull.* 164, p. 219, Dec. 1899.

[3] Sturgis, Wm. C., *op. cit.* p. 1.

I should not at this stage like to predict, and the question can only be solved by a comparative study of the two fungi.

This disease exists throughout the Union of South Africa, but is particularly bad in the Province of Natal where carnations are being largely cultivated for market purposes.

The investigation was undertaken primarily to test the growth of the fungus in pure culture in the presence of various chemicals; thus it was hoped that some light would be thrown on practical methods of control. Field experiments thus far conducted are not very conclusive and further investigations will have to be carried out in the field.

It is my pleasant duty to express my indebtedness to Mr B. A. Bell, Krantzkloof, Natal. Not only did he place his plots at our disposal for experimental purposes, but at a time when I could with difficulty leave the laboratory he kept a full record of how the experiments were going and in time submitted a very complete report.

To Mr I. B. Pole Evans, under whose direction the work was undertaken, I am grateful for many helpful suggestions and advice.

The numbers and the word "Plate" bracketed after the colours refer to the colour chart *Répertoire de Couleurs* published by the Société Française des Chrysanthémistes.

A. The Disease.

I. *Symptoms of Disease.*

The lower leaves of the plants die and the sides turn upwards, the colour changes to a sickly white and the leaves are more upright than are those of healthy plants. The upper leaves have a withered and shrivelled appearance, and soon the affected plant is dead. The bast of the stem in the affected area is most frequently soft and easily separated from the wood. Badly diseased plants, when pulled, usually break off in this region slightly below the soil. The xylem or wood just above this rotten area is brownish in colour and permeated by the threads of the causal fungus.

II. *Cause of the Disease.*

1. *Isolation of the causal fungus.* In January, 1914, a number of carnations in large tins suddenly started wilting with the symptoms given above. Small pieces of diseased tissue were sterilised in mercuric chloride (1 : 1000) and, after being washed in distilled water, were shaken up in sterilised melted beef-broth agar and poured into plates, which

were incubated at 25° C. After five days there was a pure white, fluffy, mycelial growth from the pieces of carnation, and on this growth spores typical of the genus *Fusarium*.

On two more occasions this *Fusarium* was isolated from wilting plants growing in the same tin. The fungus was also obtained from specimens submitted by Mr G. E. Ensor of Pretoria: the disease also causes serious monetary loss to carnation growers in the Province of Natal.

2. *Inoculation of carnations with the fungus in pure culture.* On the 17th February, 1914, carnation plants growing in tins at the laboratory were inoculated with the causal fungus thus: the soil was slightly removed round the stems of the plants, which were then punctured, just below the natural soil level, with a sterilised needle. Into the punctures were inserted pieces of the fungus growing in pure culture on beef-broth agar, and the soil was replaced. On the 27th February one of the inoculated plants had wilted with the usual symptoms. Pieces of diseased tissue of this plant were fixed in picroformol (formol 30 c.c., glacial acetic acid 5 c.c., water 20 c.c. and the mixture saturated with picric acid) and embedded in paraffin for further study. Beef-broth agar plates were prepared with pieces of diseased tissue and in these the same *Fusarium* developed. By the 4th March another of the inoculated plants had wilted with the characteristic symptoms mentioned above, and here too the same fungus was isolated.

In the same tin with the inoculated plants were left controls which were treated similarly to the inoculated plants in every way except that the fungus was not introduced into the punctures. These controls remained healthy.

Successful attempts at inoculation were also made by burying next to the plants cultures of the fungus. The carnations experimented on were again grown in large tins. The soil round the stems of the plants in one tin was removed; in the holes were placed cultures of the fungus on rice and the soil was then replaced. Four days later some of the plants showed a sickly appearance. On the seventh day one plant was noticed with lower leaves sickly white and upper leaves flaccid; and when this plant was pulled up it was observed to have the characteristic crown-rot. On the 13th day three more diseased plants were observed in this tin, and on the 17th the last plant had contracted the disease.

Plants growing in a tin next the inoculated tin remained healthy during this time.

During the seventeen days while this experiment was kept under observation there was a rainfall of 4·19 ins., and the night previous to placing the cultures in the soil ·47 in. of rain fell: 2·19 ins. fell within the first four days; 1·3 ins. between the 4th and 7th days. There can be little doubt that the rainfall was responsible in certain measure for the early appearance of the disease. Some of the diseased plants showed the presence of the fungus as a whitish growth on the part below the soil.

3. *The fungus in the tissues of the diseased plants.* A transverse section through the diseased area shows the fungus threads in the xylem or wood. The wilting is undoubtedly due to the fungus blocking up the vessels, decay is hastened by the entrance into the attacked region of various saprophytic bacteria, though cases were observed where bacteria were few and even altogether absent.

The fungus is also abundant in the cells of the pith and is able to invade the middle lamellae of the cells in the attacked region. The fungus also permeates the cells of the cambium, phloem and cortex, though in these regions it is less abundant than in the xylem and pith.

4. *Humidity as a factor influencing infection.* In the field it has usually been observed that the disease appears at its worst just after the first rains. This was found to be the case also with plants inoculated at the laboratory, and throws some light on the fact that plants inoculated during the dry season in some cases took a month or more before showing symptoms of the disease.

B. Growth of the Fungus in the Laboratory.

I. *Growth on Various Media at* 25° C.

Banana plugs. (Pl. XXXVII, figs. 1, 2.) Inoculated 6. vii. 14.

9. vii. 14. Dense greyish, fluffy growth.

13. vii. 14. Growth firm and compact, in places as much as 3·5 mm. thick. Surface more fluffy than on potato. Chlamydospores, both intercalary and apical, vary greatly in size, 13·2–26·4 μ diameter.

20. vii. 14. Growth where it lies on cotton wool produces a region about 2·3 mm. wide of a leaden grey (Plate 353. 3) and above this a narrow, very bright yellow region (Plate 35. 4). In places on the glass a honey yellow (Plate 35. 4) is evident. No conidia.

24. vii. 14. The light yellow region above has changed to a tan colour (Plate 317. 1). Numerous very small conidia.

Length	Breadth	Number of cells
16·5 μ	3·3 μ	4
14·85	4·75	4
19·8	4·75	4
24·75	4·75	—
23·1	6·6	—
14·85	3·3	3
19·8	3·3	4
13·2	4·75	2

Sweet Potato. (Pl. XXXVII, fig. 3.) Inoculated 15. vii. 14.

18. vii. 14. Dense grey, fluffy growth forming a felt on surface of medium.

20. vii. 14. On surface of water the fungus has formed a thick growth which where it comes into contact with the glass forms a leaden grey (Plate 353. 1) ring, above which is a very light yellow region. Chlamydospores, but as yet very few conidia.

23. vii. 14. Majority of chlamydospores have a diameter of 23·1 μ; leaden grey ring darker (Plate 353. 3), yellow above changed to a chocolate brown (Plate 342. 1). Growth 3 mm. thick; conidia abundant.

Length	Breadth	Number of cells
33·0 μ	6·6 μ	6
26·4	6·6	4
26·4	4·95	4
36·3	6·6	5
26·4	6·6	4
26·4	6·6	5
19·8	6·6	2
19·8	4·95	3
29·7	6·6	6

Sterilised Carnation stems in Petri dishes. (Pl. XXXVII, fig. 4.) Inoculated 13. vii. 14.

17. vii. 14. Dense, slightly pinkish growth, on the stalk is decidedly fluffy, but surface more mildewy. Numerous conidia of various lengths and different septations.

Length	Breadth	Number of cells
36·3 μ	6·6 μ	6
37·45	6·6	6
33	6·6	5
34·65	6·6	5
33	6·6	5

24. vii. 14. Colour on undersurface, especially in dried up plates, honey yellow (Plate 35. 4). Growth greyish rather than pink.

Sterilised Carnation leaves. (Pl. XXXVIII, figs. 5 and 7.) Inoculated 13. vii. 14.

18. vii. 14. Greyish mildewy growth (no pink). Chlamydospores intercalary, apical, or on short branches, majority 13·2–19·8μ diameter. Conidia of various lengths and septations.

Length	Breadth	Number of cells
26·4μ	4·95μ	5
26·4	6·6	4
26·4	6·6	5
19·8	4·95	3
28·05	4·95	4
24·75	4·95	3
26·4	6·6	3

24. vii. 14. On undersurface of dried up plates colour in places honey yellow (Plate 35. 4).

Potato plugs. (Pl. XXXVIII, fig. 6.) Inoculated 6. vii. 14.

9. vii. 14. Dense cottony pure white growth forming a felt-like layer 1–2 mm. thick. Mycelium swollen and macroconidia. Chlamydospores vary greatly, usually 23·1μ diameter. Conidia measure from 26·4–49·5μ in length, fusiform, septa 0–5.

18. vii. 14. On side of tube where growth comes into contact with glass, colour in places honey yellow (Plate 35. 4); on upper region of slant colour yellowish grey, below this growth more fluffy, pure white and pierced by small raised hummock-like bodies at the apex of each of which is a water-drop.

25. vii. 14. In places where growth rests on cotton-wool a leaden grey (Plate 353. 4) ring; in same neighbourhood colour in places dark chocolate brown (Plate 342. 1). Raised region light pink tinge and as much as 8 mm. thick.

Beerwort agar plates. (Pl. XXXVIII, fig. 8.) Inoculated 9. vii. 14.

18. vii. 14. Dense greyish mildewy growth, which on surface of medium is felt-like. Growth spreads all through dish. Reverse Petri dish colour yellow. This colour starts in the centre of a colony and spreads outwards.

21. vii. 14. Colour bottom of Petri dish, peach-red (Plate 98. 4). Majority of chlamydospores 16·5–26·4μ diameter.

25. vii. 14. Growth grey (Plate 359. 1) with, in places, a pink tinge, raised 2 mm. Reverse Petri dish madder-brown (Plate 334. 4). Conidia few, small, and general shape figured on banana.

Length	Breadth	Number of cells
14·35 μ	4·95 μ	2
26·4	6·6	4
26·4	4·95	4
19·8	6·6	3
19·8	6·6	4

Potato agar. (Pl. XXXIX, fig. 9.) Grey growth which in the centre is thick and fluffy-looking; about 3 mm. thick; 5·6 mm. from edge the growth is only raised about 1 mm. and radiates outwards. Colour on reverse of Petri dish, buff (Plate 309. 1). Chlamydospores 13·2–23·1μ diameter.

Measurements of conidia:

Length	Breadth	Number of cells
34·65 μ	6·6 μ	4
29·7	6·6	1
23·1	4·95	2
23·1	6·6	2
33·0	6·6	1

Liquid beerwort tubes. (Pl. XXXIX, fig. 10.) Inoculated 13. vii. 14.

20. vii. 14. Pure white cottony growth on surface of liquid; this growth creeps up the side of the tube. In one tube the following regions were evident:

(1) A leaden-grey ring (Plate 353. 1) about 3 mm. wide.

(2) Above this a rosy-flesh (Plate 134. 1) about 2 mm. wide.

(3) A very light yellow about 1 mm. wide.

(4) Above this pure white mycelial growth which creeps up the sides of the tube.

27. vii. 14. The regions in the tube above referred to are: (1) leaden-grey (Plate 353. 4); (2) rosy-flesh (Plate 134. 4); (3) mineral-brown (Plate 339. 4); (4) pure-white with yellowish places just above (3). Chlamydospores 14·85–26·4μ diameter.

Uschinsky's fluid in tubes. (Pl. XXXIX, figs. 11 and 12.) Inoculated 13. vii. 14.

20. vii. 14. In two tubes delicate mycelial growth in liquid. In remaining tube this growth has come to the surface where it forms a thick, pure white cottony growth, which climbs up the sides of the tube and rests on a light grey band.

27. vii. 14. The tube above shows the following regions in surface growth:

(1) Leaden-grey ring (Plate 353. 4).

(2) Above this mineral-brown (Plate 339. 3).

(3) Mycelium creeping up sides pure white excepting just above (2) where it is light yellow. Hanging from (1) into the liquid are two hard, wart-like bodies (above is a small pocket arrangement). A section through one of them showed nothing of peculiar interest. Chlamydospores abundant in this region. Mycelium, etc., coloured and oil globules frequently large.

Solution N + agar plates. (Pl. XL, fig. 13.) Inoculated 18. vii. 14.

22. vii. 14. In first two plates thick greyish felt-like growth covering whole Petri dish, furrows where originally separate colonies come into contact. Later plates colonies greyish, thick, dense in centre, towards periphery mildewy with a light pink tinge, raised 1–15 mm.

29. vii. 14. Growth creeps up sides of Petri dishes, mildewy. Colour on reverse of Petri dishes: (1) where growth touches glass, carrot-red (Plate 55. 1); (2) where growth is raised, mineral-brown (Plate 339. 4). Chlamydospores 19·8–33·0μ diameter.

Conidia:

Length	Breadth	Number of cells
26·4 μ	6·6 μ	4
29·7	4·95	4
26·4	6·6	4
23·1	6·6	4
26·4	4·95	—
29·7	6·6	6
26·4	6·6	6

Raulin's fluid. (Pl. XL, fig. 14.) Inoculated 13. vii. 14.

20. vii. 14. In all tubes colourless mycelial growth in liquid. This growth has not yet reached the surface on 22. vii. 14. Tubes shaken up so as to get growth to the surface.

27. vii. 14. Surface growth good.

31. vii. 14. The following regions in all the tubes:

(1) Leaden-grey (Plate 353. 1) 4–7 mm. wide.
(2) Pure white growth creeping up sides of tube.
(3) Between the above—a very light yellow tint.

6. viii. 14. Majority of chlamydospores 16·5–19·8μ diameter. Following regions:

(1) Leaden-grey (Plate 353. 4).
(2) Rosy flesh (Plate 134. 4) 3 mm. wide.
(3) Pale buff (Plate 64. 4).
(4) Above this pure white creeping up sides of tubes. Growth below warty and of a fleshy colour.

Turnip tubes. (Pl. XL, fig. 15.) Inoculated 1. viii. 1914.

5. viii. 14. Growth dense, greyish, fluffy to cottony. Conidia sparse with septa indistinct.

Length	Breadth
16·5 μ	5·775 μ
18·8	5·775
19·8	4·95
21·45	4·95
19·8	4·95
18·15	6·6
16·5	4·95

Chlamydospores 13·2–19·8μ diameter.

21. viii. 14. Growth 3–4 mm. thick, in places on surface greyish yellow. In some tubes raised hummock-like white bodies. In places along the glass, bronze-yellow (Plate 34. 3). Just above cotton-wool there is most frequently a leaden grey ring (Plate 353. 4) which may be yellowish in patches. Conidia abundant.

II. *Growth in the Absence of Free Oxygen.*

To test whether the fungus is able to grow in the absence of free oxygen, fermentation tubes containing the following media were inoculated: Uschinsky's fluid, Raulin's fluid, liquid beef-broth, liquid beerwort. Two tubes of each medium were inoculated, by removing

a small piece of the fungus on agar and pressing it past the bend of the fermentation tubes; another piece of growth was placed on the surface of the liquid in the open end. The pieces pressed past the bend in some ascended halfway only or after going right up came down again and stopped halfway.

Inoculated 13. vi. 14. *Incubated* 25° C.

Medium	Dates of examination	Result: Growth on surface	Result: Growth from piece past bend
Uschinsky's solution	1. vii. 14	Vigorous	0
Raulin's fluid	1. vii. 14	Vigorous	0
Liquid beef-broth	1. vii. 14	Vigorous	0
Liquid beerwort	1. vii. 14	Vigorous	0

The results enumerated above clearly show that the fungus is unable to take its oxygen from the compounds contained in any of the four liquids used. As far as could be determined, the fungus appears to be strictly aerobic.

III. *Temperature Relations.*

Tubes of various media were inoculated with the fungus obtained from a beef-broth agar culture, and incubated at the temperature stated in the table below. Two tubes of each medium were incubated at each temperature.

Date of inoculation: 24. viii. 14.

Temperature	Dates of examination	Media used and growth at different temperatures: Beerwort slants	Rice tubes	Uschinsky's solution	Sweet potato tubes
0° C.	26. viii. 14	No growth in any of the cultures			
	28. viii. 14	No growth in any of the cultures			
15° C.	26. viii. 14	Good	No visible growth	Feeble	Good
	28. viii. 14	Vigorous	Feeble	Good	Vigorous
25° C.	26. viii. 14	Vigorous	Good	Vigorous	Vigorous
	28. viii. 14	,,	Vigorous	,,	,,
30° C.	26 viii. 14	Vigorous	Vigorous	Vigorous	Vigorous
	28. viii. 14	,,	,,	,,	,,
37° C.	26. viii. 14	Starting	Starting	Exceedingly feeble	Exceedingly feeble
	28. viii. 14	Feeble	Feeble	Feeble	Feeble
40° C.	26. viii. 14	No growth in any of the cultures			
	28. viii. 14	No growth in any of the cultures			

Note 1. 26. viii. 14. At 30° C. the growth was in every instance more vigorous than at 25° C.

Note 2. 28. viii. 14. Growth at 25° C. and 30° C. equally vigorous At 15° C. less than at 25° C., and at 37° C. less than at 15° C.

Note 3. 31. viii. 14. Very little difference between growths at 25° C. and 30° C. on the one hand and 15° C. on the other. At 37° C. no further growth and feeble as compared with growth at 25° C. and 30° C.

On 31. viii. 14 all the cultures were incubated at 30° C. with the results expressed in the table below.

Former temperature	Dates of examination	Media and growth of cultures exposed above at 0° C., 37° C. and 40° C., and from 31. viii. 14 at 30° C.			
		Beerwort agar slant	Rice tubes	Uschinsky's solution	Sweet potato tubes
0° C.	2. ix. 14	Vigorous	Vigorous	Vigorous	Vigorous
37° C.	2. ix. 14	In all cultures vigorous; about equal to above			
40° C.	2. ix. 14	No growth in any of the cultures			
	4. ix. 14	No growth in any of the cultures			

IV. *Growth in beef-broth agar of various alkalinities on Fuller's scale*[1].

Inoculated 18. v. 14. *Incubated* 25° C.

Reaction of medium on Fuller's scale	Dates of examination	Sodium hydrate (caustic soda)	Sodium carbonate (washing soda)
−15	20. v. 14	Vigorous	Vigorous
−25	20. v. 14	Vigorous	Vigorous
−35	20. v. 14	Good	Good
−40	20. v. 14	Good	Feeble
−45	20. v. 14	Feeble	Feeble

Inoculated 4. vii. 14. *Incubated* 25° C.

Note. As the agar did not set firm on the slant, the tubes were not stood upright.

Reaction of medium on Fuller's scale	Dates of examination	Sodium hydrate (caustic soda)	Sodium carbonate (washing soda)
−70	6. vii. 14	Good	Good
	8. vii. 14	Vigorous	Vigorous
−80	6. vii. 14	Feeble	Fair
	8. vii. 14	Good	Vigorous
−85	6. vii. 14	Feeble	Fair
	8. vii. 14	Good	Good
−95	6. vii. 14	Very feeble	Feeble
	8. vii. 14	Feeble	Good
−100	6. vii. 14	—	Feeble
	8. vii. 14	Very slight	Good
Control	6. vii. 14	Vigorous	—

In reacts − 70 F. to − 100 F. the growth in the presence of sodium hydrate was in every case less vigorous than in tubes containing sodium carbonate in which latter again the growth was less vigorous than in the controls.

[1] Fuller's scale expresses the amount of normal acid or alkali required to neutralise 1000 c.c. of an alkali or acid solution. Thus −15 F. means that the medium is alkaline and that 1000 c.c. requires 15 c.c. of a normal acid to neutralise it. Similarly +15 F. implies that the medium is acid and that a 1000 c.c. of it will be neutralised by 15 c.c. normal alkali.

V. *Growth in Rice of various acidities*[1] *with Hydrochloric, Nitric and Sulphuric Acids.*

In acidities – 30 F., – 60 F. the growth was in three days as vigorous as in the controls. In hydrochloric and sulphuric acid – 80 F., – 105 F. the growth within three days was less vigorous than in the controls, but within five days they came up to the controls. Growth in acidities higher than – 105 F. is given in the tables below.

Inoculated 14. vii. 14. *Incubated* 25° C.

Reaction on Fuller's scale	Dates of examination	Nitric	Hydrochloric	Sulphuric
+110	17. vii. 14	Fair	Fair	Slight
	20. vii. 14	Vigorous	Vigorous	Vigorous
	28. vii. 14	Mouse colour[2] (360. 2) and canary yellow (17. 4)	Terra cotta (331. 4)	Slate grey (362. 2)
+120	17. vii. 14	Slight	—	Slight
	20. vii. 14	Vigorous	Vigorous	Vigorous
	28. vii. 14	Ashy grey (358. 3) Canary yellow (17. 4) Brown lake (336. 1)	Smoke grey (363. 1)	Smoke grey (363. 1)
+130	17. vii. 14	Slight	—	Slight
	23. vii. 14	Vigorous	—	Vigorous
	28. vii. 14	Canary yellow (17. 4) Mouse colour (360. 2)	Vigorous Terra cotta (331. 1)	Terra cotta (331. 1)
+140	17. vii. 14	Slight	—	Slight
	23. vii. 14	Vigorous	—	Good
	28. vii. 14	Canary yellow (17. 4) Ashy grey (358. 3)	Feeble	Vigorous
+160	17. vii. 14	Slight	—	—
	23. vii. 14	Vigorous	—	Feeble
	28. vii. 14	Canary yellow (17. 4) Dark chocolate brown (342. 4)	Feeble	Feeble

[1] The acidity of the rice was determined by placing a known weight of ground rice overnight in a known volume of neutral alcohol. Next morning the alcohol was filtered off, titrated and the acidity determined on Fuller's scale. Five grams of the rice were then placed in a wide test-tube and 5 c.c. of water containing enough acid to produce the required reaction added. The tubes were sterilised on the slant in the autoclave at 110–120° C. for 15 mins. and then inoculated with the fungus mycelium by removing small pieces of agar with the fungus on it and mixing this with the rice.

[2] The colour is that noticed in contact with the glass and the numbers refer to the *Répertoire de Couleurs* published by the Société Française des Chrysanthémistes.

Inoculated 31. ix. 14. *Incubated* 25° C.

Reaction on Fuller's scale	Dates of examination	Nitric	Hydrochloric	Sulphuric
+170	2. x. 14	Starting	—	Starting
	7. x. 14	Vigorous Lake brown	—	Vigorous
	10. x. 14	Canary yellow (17. 4)	—	Rosy flesh (134. 4)
			—	
+190	2. x. 14	Starting	—	Starting
	7. x. 14	Vigorous. Colour as above	Good	—
	10. x. 14	—	Rosy flesh (134. 4)	Good
+210	2. x. 14	—	—	Starting
	7. x. 14	—	—	Feeble growth from piece of agar on rice
	10. x. 14	—	—	No better
+220	2. x. 14	—	—	Feeble growth, starting
	10. x. 14	Feeble	—	—
+240	2. x. 14	No growth in any of the tubes		
	10. x. 14	No growth in any of the tubes		
Control	2. x. 14	Vigorous white growth. Colour on glass pearl grey (354. 4) with, in patches, canary yellow (17. 4).		
	10. x. 14	Colour on glass terra cotta (331. 1) and pearl grey.		

Note. On the rice kernels small black pycnidia-like bodies were frequently observed. No spores were found in them and they would appear to be of the nature of sclerotia.

VI. *Experiments in the Laboratory with various Soil Fungicides.*

The quantities stated in the tables below were added to 50 c.c. neutral beef-broth agar. The formalin, carbolic acid and hycol solutions were added after sterilisation and the flasks immediately inoculated. The other substances were added before sterilisation and the flasks then autoclaved. The flasks were inoculated by dropping into them pieces of the fungus on beef-broth agar and then shaking up well. All the cultures were incubated at 25° C. and controls in every instance incubated at the same time.

SERIES I. 1 c.c. *Formalin diluted with* 100 c.c. *Distilled Water.*

Dates of inoculation	Dates of examination	Quantities of 1 % formalin solution added to 50 c.c. neutral beef-broth agar							
		·3 c.c.	·6 c.c.	·7 c.c.	·9 c.c.	1 c.c.	1·5 c.c.	2 c.c.	2·5 c.c.
11. v. 14	13. v. 14	Good	Good	Good	Starting	Good	No growth		
	15. v. 14	As vigorous as controls					Slight growth just starting		
14. v. 14	18. v. 14	—	—	—	—	—	Good	No growth	No growth

SERIES II. 1 gm. *Carbolic Acid dissolved in* 100 c.c *Distilled Water.*

Dates of inoculation	Dates of examination	Quantities of 1 % carbolic acid added to 50 c.c. neutral beef-broth agar						
		·3 c.c.	·6 c.c.	·7 c.c.	·9 c.c.	1 c.c.	1·5 c.c.	2 c.c.
11. v. 14	13. v. 14	Good	Good	Vigorous	Good	Good		
	15. v. 14	Vigorous	Vigorous	Vigorous	Vigorous	Vigorous		
14. v. 14	18. v. 14	—	—	—	—	Vigorous	Slight	Less than 1·5
		2 c.c.	3 c.c.	3·5 c.c.	4 c.c.	5 c.c.		
26. v. 14	31. v. 14	Fair	Fair	Feeble	Slight growth from piece in agar	Very slight growth from piece in agar		
	6. vi. 14	—	—	Vigorous	—	Growth from piece in agar not yet reached surface		
						5·5 c.c.	6 c.c.	6·5 c.c.
9. vi. 14	15. vi. 14	—	—	—	—	No growth	No growth	No growth
	20. vi. 14	—	—	—	—	No growth	No growth	No growth

SERIES III. 1 c.c. *Hycol in* 100 c.c. *Distilled Water.*

Dates of inoculation	Dates of examination	Quantities of 1 % hycol added to 50 c.c. neutral beef-broth agar						
		·3 c.c.	·6 c.c.	·7 c.c.	·9 c.c.	1 c.c.	1·5 c.c.	2 c.c.
14. v. 14	18. v. 14	Good	Good	Good	Good	Good	Good	Good
		2 c.c.	3 c.c.	3·5 c.c.	4 c.c.	5 c.c.		
26. v. 14	31. v. 14	Vigorous	Vigorous	Vigorous	Slight	Slight		
	6. vi. 14	,,	,,	,,	Vigorous	Vigorous growth from piece in agar spreading over surface		
		5·5 c.c.	6 c.c	6·5 c.c.				
9. vi. 14	12. vi. 14	Fair growth from pieces in agar	Slight growth from pieces in agar	Slight growth from pieces in agar				
	15. vi. 14	Vigorous	Vigorous all over	Vigorous all over				

SERIES IV. *Crushed Quicklime.*

Dates of inoculation	Dates of examination	Weights of quicklime added to 50 c.c. neutral beef-broth agar						
		·1 gm.	·3 gm.	·5 gm.	·6 gm.	·7 gm.	·9 gm.	1 gm.
6. v. 14	9. v. 14	Good	No growth	Starting	Starting	No growth	No growth	No growth
	11. v. 14	Vigorous	Vigorous	Good	Good	Slight	Slight	No growth
	13. v. 14	—	—	—	—	—	—	Starting
		1 gm.	1·5 gms.	2 gms.	2·5 gms.			
2. vi. 14	5. vi. 14	No growth	No growth	No growth	No growth			
	8. vi. 14	,, ,,	,, ,,	,, ,,	,, ,,			
	12. vi. 14	,, ,,	,, ,,	,, ,,	,, ,,			

SERIES V. *Crushed Kainit.*

Dates of inoculation	Dates of examination	Weights of kainit added to 50 c.c. neutral beef-broth agar						
		·1 gm.	·3 gm.	·5 gm.	·6 gm.	·7 gm.	·9 gm.	1 gm.
6. v. 14	9. v. 14	Good	Good	Good	Good	Good	Good	Feeble
	11. v. 14	Vigorous	Vigorous	Vigorous	Vigorous	Vigorous	Vigorous	Vigorous
			1·5 gms.	2 gms.	3 gms.	4 gms.		
2. vi. 14	5. vi. 14	—	Vigorous	No growth	No growth	No growth		
	8. vi. 14	—	,,	,, ,,	,, ,,	,, ,,		
	12. vi. 14							

SERIES VI. *Lithium Nitrate.*

Dates of inoculation	Dates of examination	Weights of lithium nitrate added to 50 c.c. neutral beef-broth agar						
		·1 gm.	·3 gm.	·5 gm.	·6 gm.	·7 gm.	·9 gm.	1 gm.
6. v. 14	9. v. 14	Vigorous	Vigorous	Vigorous	Vigorous	Feeble	No growth	Feeble
	11. v. 14	—	—	—	—	Vigorous	Feeble	Feeble
		1·5 gms.	2 gms.	2·5 gms.				
2. vi. 14	5. vi. 14	Slight	No growth	No growth				
	8. vi. 14	Feeble	,, ,,	,, ,,				
	12. vi. 14							

SERIES VII. *Copper Carbonate.*

Date of inoculation	Dates of examination	Weights of copper carbonate added to 50 c.c. neutral beef-broth agar					
		·1 gm.	·3 gm.	·5 gm.	·7 gm.	·9 gm.	1 gm.
2. vi. 14	5. vi. 14	Vigorous	No growth	No growth	No growth	No growth	No growth
	8. vi. 14	,,	,, ,,	,, ,,	,, ,,	,, ,,	,, ,,
	12. vi. 14						

SERIES VIII. *Sodium Chloride (common salt).*

Date of inoculation	Dates of examination	Weights of salt added to 50 c.c. neutral beef-broth agar					
		3·5 gms.	4 gms.	4·5 gms.	5 gms.	5·5 gms.	6 gms.
3. vii. 14	5. vii. 14	No growth	No growth	No growth	No growth	No growth	No growth
	8. vii. 14	Vigorous	Vigorous	Good	Good	,, ,,	,, ,,
	10. vii. 14	—	—	Vigorous	Vigorous	Vigorous	

C. Field Experiments.

Mr B. A. Bell of Krantzkloof, Natal Province, very kindly assisted in allowing field experiments to be carried out at his place. This place particularly suited our purpose as the soil was very badly infected since diseased plants had inadvertently been dug in.

The experimental plots were situated on a gentle slope, facing north. Each plot was about 70 × 40 ft. The soil was a sandy loam.

The area placed at our disposal was divided into six plots and these plots treated as follows:

Plot A. Crushed quicklime at the rate of two tons to the acre. The quicklime was applied as a surface dressing on the 21st September; raked in on the 1st October and again raked over on the 7th October.

Plot B. Control.

Plot C. Crushed quicklime at the rate of 3 tons to the acre. Applied and treated as for plot *A*.

Plot D. Crushed quicklime at the rate of 5 tons to the acre. Applied and treated as for plot *A*.

Plot E. Control.

Plot F. One per cent. formalin applied at the rate of 2000 gallons to the acre. The soil was watered with the formalin solution on the 29th September and raked over on the 1st and 7th October.

The planting of carnations was commenced on the 15th October and continued on the 16th, 17th, 21st, 22nd and 23rd. The weather remained good; cloudy and showery but not enough to stop work; the ground being kept just moist enough.

In planting each plot was divided into six sections and planted as under:

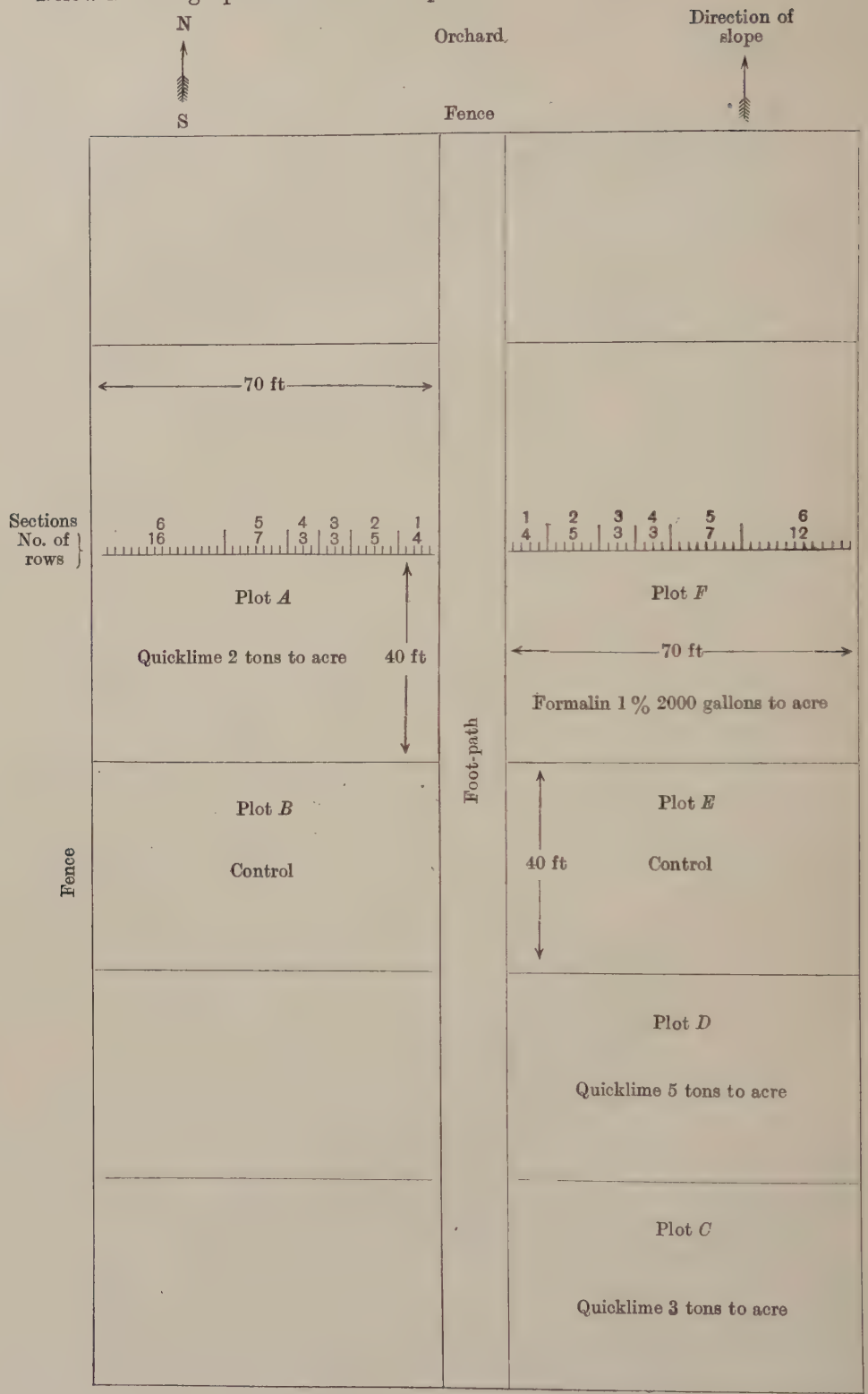
Section	Distinguishing feature	No. of rows
1	Pink tree, raised by Mr Bell	4
2	Pink tree[1], obtained by Mr Bell from a friend	5
3	Named varieties[2], own raising	3
4	Common red[3] (little value)	3
5	Pink tree, obtained from another friend ...	7
6	Pink tree mixed with common red and named varieties	
	Plots *A* and *B*	16
	Plots *C* and *D*	12
	Plots *E* and *F*	11

[1] An unhappy lot of plants from the beginning.

[2] The varieties were: Georgia, My Maryland, Andrew Carnegie, Mrs Henry Lawson, Regina, Lady Bountiful, La Mode, Verita.

[3] Very promising plants.

Below is a rough plan of the area experimented on.



On the 2nd December Mr Bell inspected the plots and wrote "noticed that a fair number of plants had died, though in some cases evidently from drought, from inherent weakness as well as from disease."

On December 21st he counted the surviving plants and submitted the following report: "Those unmistakably diseased were counted separately from the apparently healthy plants, and as far as my judgment went a distinction being made between 'Wilt' and 'Eelworm.'" Mr Bell's results are tabulated below[1].

Report on Plots examined 21st December, 1914.

Plot	Section	Original total	Healthy plants	Wilting	Eelworm	Blanks
A.	1	120	36	1	1	82
Quicklime	2	150	132	—	—	18
2 tons to	3	90	74	1	—	15
acre	4	90	35	—	—	55
	5	210	141	6	4	59
	6	480	222	—	—	258
	Totals ...	1140	640	8	5	487
B.	1	120	22	1	4	95
Control	2	150	119	—	1	30
	3	90	73	4	—	17
	4	90	6	—	7	77
	5	210	148	4	10	48
	6	480	132	19	18	311
	Totals ...	1140	500	28	40	578
C.	1	120	47	3	10	60
3 tons	2	150	90	2	5	53
quicklime	3	90	67	4	10	9
to the acre	4	90	27	5	8	50
	5	210	111	21	31	47
	6	360	98	2	31	229
	Totals ...	1020	440	37	95	448
D.	1	120	53	2	11	54
5 tons	2	150	89	—	4	57
quicklime to	3	90	79	2	1 (1 broken)	7
the acre	4	90	43	3	8	36
	5	210	92	5	55	58
	6	360	122	16	37	185
	Totals ...	1020	478	28	116	397

[1] [The numbers given in the tables are not in all cases exactly correct, as the horizontal and vertical totals do not always agree with the sums of the items (ED.).]

Plot	Section	Original total	Healthy plants	Wilting	Eelworm	Blanks
E.	1	120	15	9	22	74
Control	2	150	100	3	11	36
	3	90	72	2	2 (4 broken)	10
	4	90	36	—	7	47
	5	210	63	14	40	93
	6	330	86	7	21	216
	Totals ...	990	372	35	103	476
F.	1	120	19	4	12	85
2000 gallons	2	150	79	—	10	61
1 % formalin	3	90	85	3	—	2
to acre	4	90	19	9	19	43
	5	210	70	10	44	86
	6	330	96	12	23	199
	Totals ...	990	368	38	108	476

In the table below the results of the experiments are reduced to percentages calculated on the totals in each plot.

	Plots ...	*A*	*B*	*C*	*D*	*E*	*F*
	How treated	2 tons quicklime to acre	Control	3 tons quicklime to acre	5 tons quicklime to acre	Control	2000 gallons 1 % formalin to acre
	Original number of plants	1140	1140	1020	1020	990	990
21 Dec. 1914	% wilting	·701	2·45	3·62	2·24	3·53	3·83
	% blanks	42·71	50·701	47·84	36·96	48·08	48·08
	% healthy	56·14	43·85	43·3	46·86	37·57	37·15

These experiments would tend to indicate that (1) formalin has no beneficial result on the disease; (2) the plots treated with quicklime were slightly better than the controls but other experiments would be necessary before arriving at any definite conclusion.

D. Methods of Control.

The fungus causing this disease is essentially a soil organism. Methods of control should hence aim at preventing soil from becoming contaminated with the fungus rather than getting rid of it when once in the soil.

Soil once contaminated undoubtedly retains the disease germs for years and the organism can only be got rid of by disinfecting the soil. Thus Sturgis suggests disinfecting the beds with steam, a method which as yet has not proved practicable on a large scale though undoubtedly excellent for greenhouse purposes in which case the whole building should be disinfected.

The most practical method would appear to resort to crop-rotation, a process which has proved itself a cleansing factor in garden economy. Even if in order to practise crop-rotation it should be necessary to have additional ground, the money will be well spent, and at the end will be found more profitable than placing cuttings in diseased ground.

When once the disease is noticed prompt action is necessary. Diseased plants should be immediately uprooted and destroyed; to leave them standing or to dig them in would simply mean propagating the disease.

It has been shown that soil organisms are also spread by: (1) water running from or through a higher diseased area to a healthy lower area; (2) through the soil adhering to the boots of gardeners or feet of animals; (3) by using tools on an infected area and, without first sterilising, transferring them for use on healthy soil.

Attempts should be made as far as practicable to prevent the disease from spreading by one or any of the above methods.

Sturgis[1] had reason for believing that the fungus may be carried over in diseased cuttings. I, too, have observed instances where this appears highly probable and would strongly suggest that growers take cuttings only from healthy plants and lay them in in a healthy soil. As far as possible, it would appear advisable for growers to grow their own stock and not resort, to the, at times, objectionable process, frequently accompanied by serious consequences, of obtaining cuttings from their neighbours.

Summary.

1. The disease in the carnation here commonly referred to as "Wilt" or "Crown-rot" is caused by a fungus belonging to the genus *Fusarium*.

2. The disease usually shows as a wet rot of the stem just below the soil. The lower leaves turn a sickly colour, are usually more erect and soon the whole plant is dead.

3. This fungus was isolated from diseased carnations; grown in

[1] Sturgis, Wm. C., *op. cit.* p. 1.

the laboratory and when inoculated into healthy plants produced the disease.

4. The organism grew well on all culture media, producing usually a greyish growth. Along the glass of the tubes and the bottom of Petri dishes, it showed shades of grey, yellow, brown and red.

5. The fungus grows best at 25°–30° C., with something in favour of the latter temperature. No growth at 0° C. or 40° C. At 15° C. growth less vigorous than at 25° C.: at 37° C. it remains feeble. The fungus is not killed by incubation at 0° C.; cultures from 0° C. and 37° C. transferred to 30° C. showed a vigorous growth. No growth occurred in cultures transferred from 40° C. to 30° C.

6. The organism appears to be strictly aerobic.

7. It withstands high degrees of acidity but less alkalinity.

8. Conidia vary in size in different media and range between 14·85–37·95μ × 3·3–6·6μ, hyaline, fusiform to nearly straight, on some media (banana) very small; 2–6 celled.

9. Experiments were carried out in the laboratory with various disinfectants and fungicides; these experiments serve to act as a guide for experiments on the treatment of infected soil.

10. Field experiments carried out with the object of finding whether the application of quicklime or formalin solution to diseased soils would have any beneficial effect, tend to show: (*a*) the plot treated with formalin was no better than the control plots; (*b*) on the whole, the plots treated with quicklime fared a little better than the controls, but further experiments would be necessary.

11. It is urged that the spread of the disease should be prevented as far as practicable by: (*a*) growing one's own cuttings; (*b*) obtaining cuttings from healthy vigorous plants only; (*c*) laying cuttings in in healthy ground; (*d*) pulling up and destroying all plants showing any evidence of disease.

12. Diseased soil should be submitted to a judicious process of crop-rotation for a few years, and all attempts made to prevent the fungus spreading from diseased to healthy areas.

13. The question of the existence of varieties more or less immune from the disease has thus far not received attention, though it is a problem well worth serious consideration, and the breeding of disease-resistant varieties may yet be the ultimate solution.

The Botanical Laboratories of the
Union of South Africa, Pretoria.
January, 1915.

Fig. 1

Fig. 2

Fig. 3

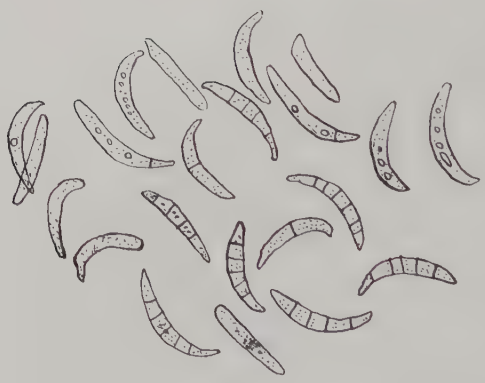


Fig. 4

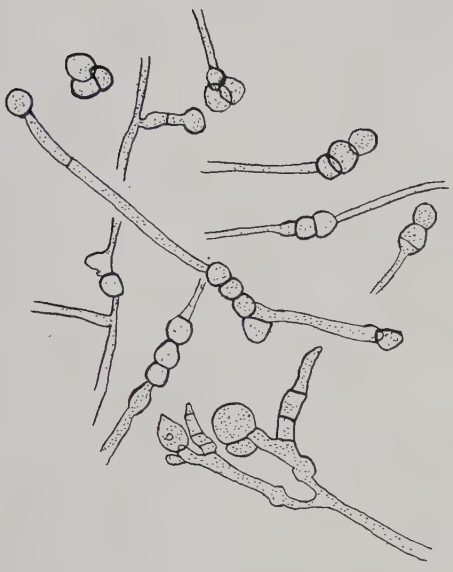


Fig. 5

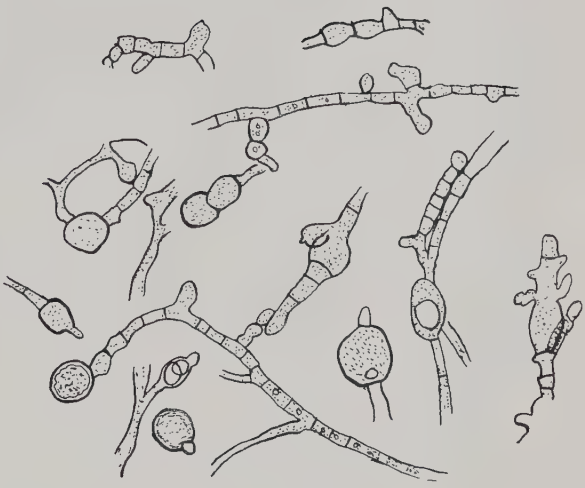


Fig. 6

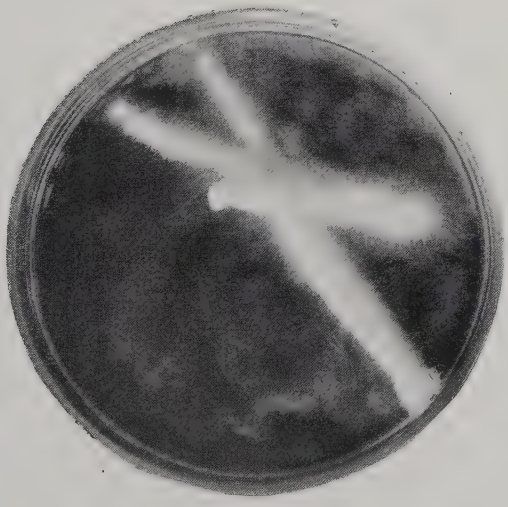


Fig. 7

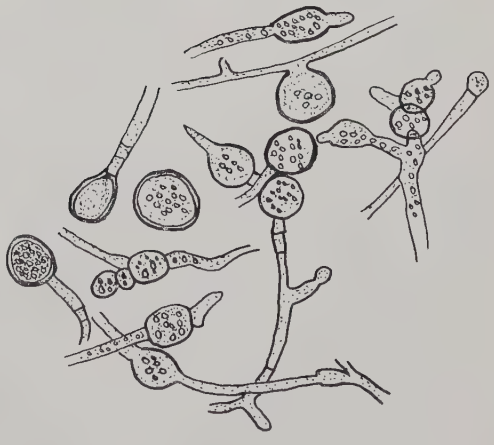


Fig. 8

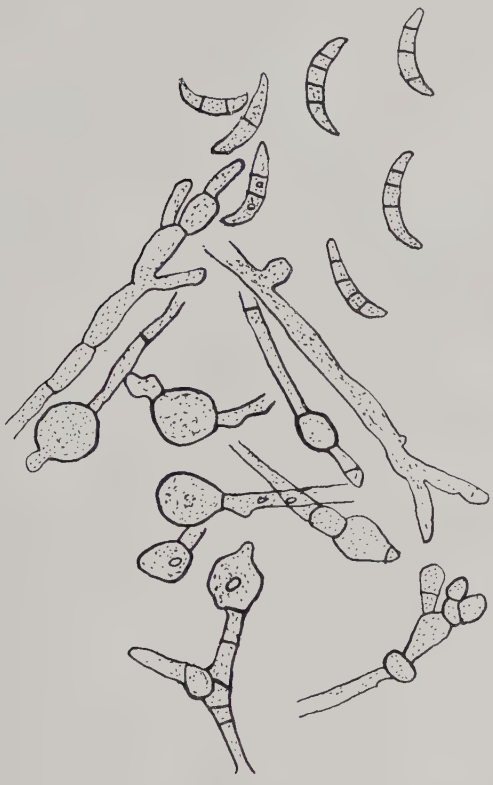


Fig. 9

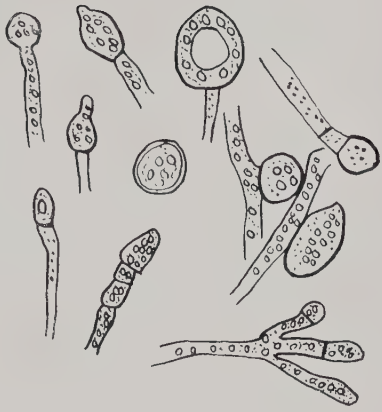


Fig. 10

Fig. 11

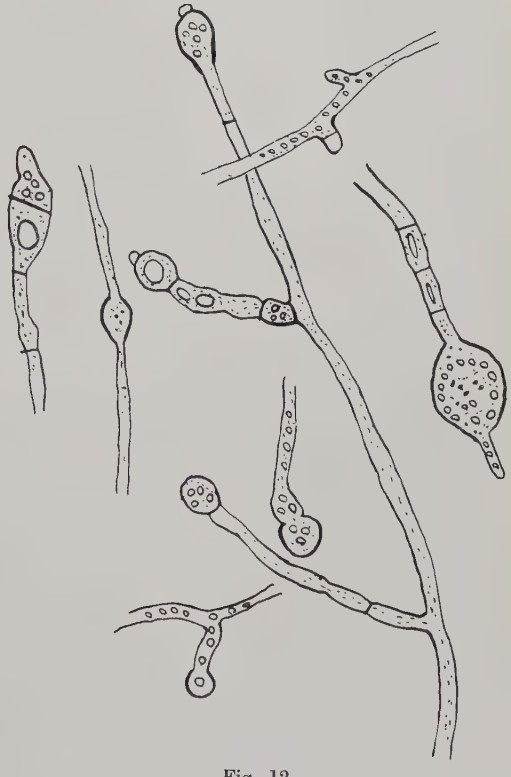


Fig. 12

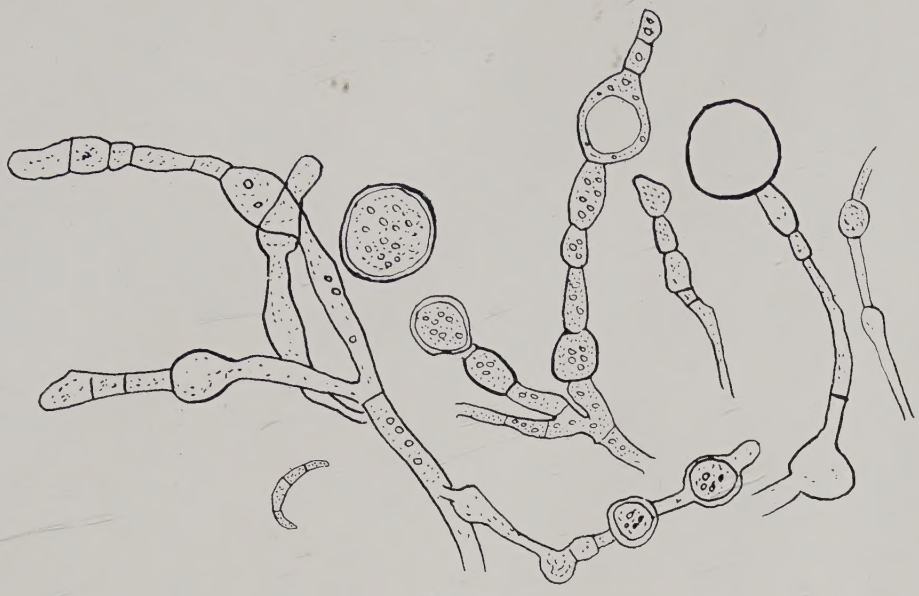


Fig. 13

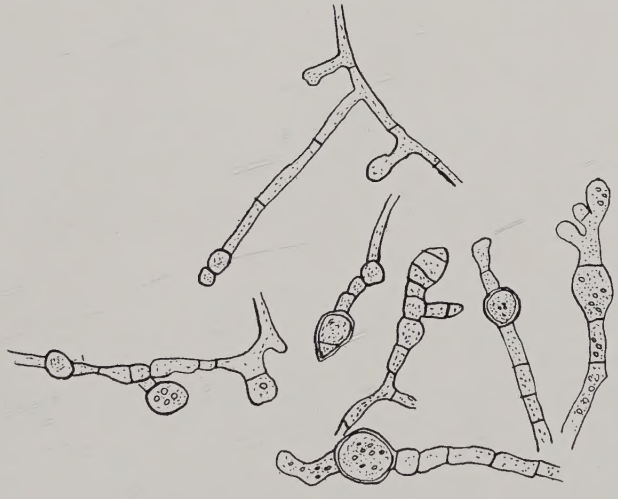


Fig. 14

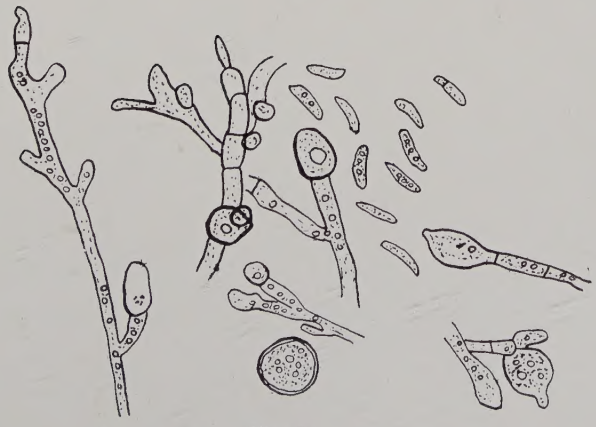


Fig. 15

EXPLANATION OF PLATES.

PLATE XXXVII.

Fig. 1 (×400). Drawing of fungus on banana. 12 days 25° C.
Fig. 2 (×400). Spores of the fungus on banana. 18 days 25° C.
Fig. 3 (×400). Drawing of fungus and spores on sweet potato. 8 days 25° C.
Fig. 4 (×400). Spores on sterilised carnation stalks. 4 days 25° C.

PLATE XXXVIII.

Fig. 5 (×400). From sterilised carnation leaves.
Fig. 6 (×384). From potato plug. 5 days 25° C.
Fig. 7. On sterilised carnation leaves. 5 days 25° C.
Fig. 8 (×400). Beerwort agar, from growth growing up sides of Petri dish. 12 days 25° C.

PLATE XXXIX.

Fig. 9. Fungus and spores on potato agar. 10 days 25° C.
Fig. 10 (×400). Fungus from liquid beerwort. 14 days 25° C.
Fig. 11. Photograph showing wart-like bodies formed in Uschinsky's solution. 14 days 25° C.
Fig. 12 (×400). Fungus from Uschinsky's solution. 14 days 25° C.

PLATE XL.

Fig. 13 (×400). From solution N and agar. 11 days 25° C.
Fig. 14 (×400). From Raulin's fluid. 21 days 25° C.
Fig. 15 (×400). From turnip tubes. 4 days 25° C.

REVIEW

Dr J. A. NELSON. *The Embryology of the Honey-Bee.* (Princeton University Press, London; Oxford University Press, 1915.) Pp. 282. Price 8*s.* 6*d.*

In this little book, although the author is "Expert in Bee-Culture Investigations" in the Department of Agriculture, Washington, we find no reference whatever to any of the problems suggested by bee-culture: we have only an account of the early stages in the development of the bee up till the time that it emerges as a grub from the egg-shell and takes up its existence within a cell of the honeycomb. To the student of comparative embryology however as distinguished from the economic zoologist the book is welcome, for it gives a most painstaking and thorough account of the formation of the blastoderm in the egg, of the differentiation of ectoderm, endoderm, and mesoderm, and of the manner in which these three layers are transformed into the most important organs of the grub. About the formation of these layers in insects there had developed a good deal of controversy. Heymons had maintained that in the higher insects, the endoderm, after giving rise to cells which assisted in liquefying the yolk, disappeared, and that the midgut was lined by ectodermal cells which grew in from the mouth and anus. Now this view, which would upset all our ideas as to the fundamental functional distinctions between the germ-layers, was opposed by Hirschler who maintained that Heymons had been misled by gaps in the series of stages which he examined, and that the endoderm in the higher insects as in the lower forms the epithelium of the midgut. In the volume before us Dr Nelson gives convincing proof that Hirschler is right at least so far as the honey-bee is concerned. The book is admirably illustrated: a number of plates illustrating whole mounts are collected at the end, whilst interspersed with the text are a number of figures illustrating the development of particular organs. The technique employed is carefully explained and there are a number of valuable hints on the effects of different kinds of preserving fluids. The book will constitute a welcome addition to the library of the scientific zoologist.

E. W. M.